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INSIDE THIS ISSUE:

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Tutorial—Improving Matching Network Bandwidth
Power Combiners, Impedance Transformers and Couplers
New Products—ADCs & DACs, Switches, Capacitors & Inductors
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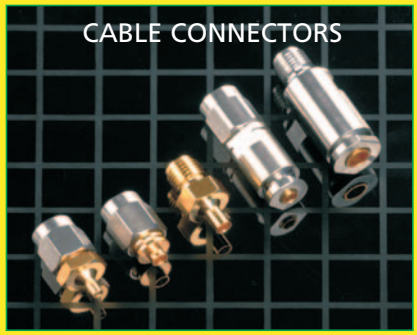

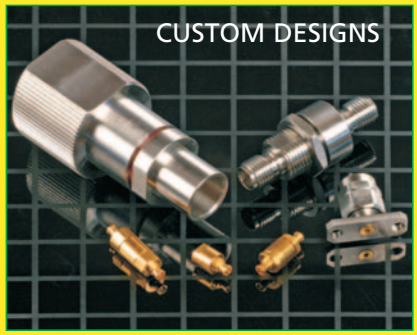

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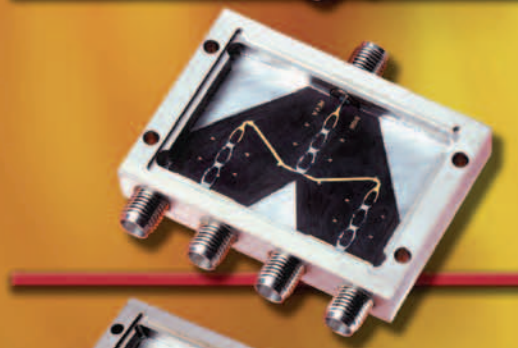

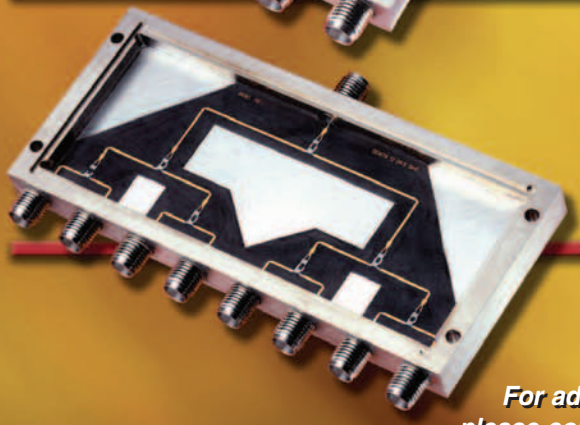

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Insertion loss	dB		2.5
Isolation	dB	17	
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Output VSWR	Ratio		1.7
Phase unbalance	Degrees		±5.0
Amplitude balance	dB		±0.5
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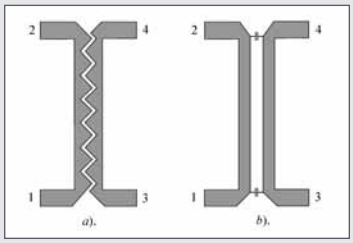

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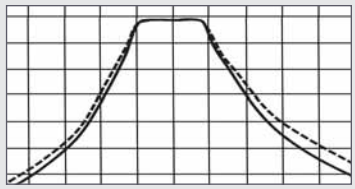

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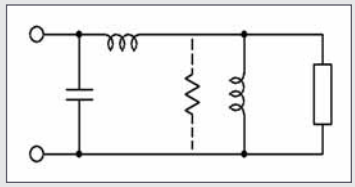

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Editorial Director
Gary Breed
gary@highfrequencyelectronics.com
Tel: 608-437-9800
Fax: 608-437-9801

Publisher
Scott Spencer
scott@highfrequencyelectronics.com
Tel: 603-472-8261
Fax: 603-471-0716

Associate Publisher
Tim Burkhard
tim@highfrequencyelectronics.com
Tel: 707-544-9977
Fax: 707-544-9375

Associate Editor
Katie Landmark
katie@highfrequencyelectronics.com
Tel: 608-437-9800
Fax: 608-437-9801

Business Office
High Frequency Electronics
7 Colby Court, Suite 7-436
Bedford, NH 03110

Editorial and Production Office
High Frequency Electronics
104 S. Grove Street
Mount Horeb, WI 53572

Also Published Online at
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Subscriptions
Sue Ackerman
Tel: 651-292-0629
Fax: 651-292-1517
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Wireless Applications for These Difficult Economic Times

Gary Breed
Editorial Director

We are facing many economic challenges here in the U.S. Since the boom times of the 1990s ended in late 2000 and early 2001, our government has spent too much and collected too little revenue. Businesses have reorganized, borrowed and merged as much as they are able. Many individuals have run up too much debt by continuing to spend while their real income has dropped. The wave of economic growth and strength has its peak elsewhere in the world, while a trough is what we are experiencing here.

I won't try to play economist and promote a particular remedy, but I can offer some ideas for wireless applications that seem to make sense when times are tough.

With apologies to Mr. Greenspan, I'd first like to note the "irrational exuberance" of the handset market. While handsets are an extremely important part of the high frequency marketplace, growth is being pursued mainly through gadgets and optional services. Sure, they are attractive to many of us, but when times are difficult they are unnecessary luxuries for those consumers who just can't afford another $20 (or more) per month for those features and services. Companies should keep working on new technologies and new features; their prime time will come eventually. Just don't be surprised if they don't meet overly optimistic market projections for the next year or two.

There are lots of other things that are excellent choices for these challenging times—things that save time and money for their users. Remote utility meter reading not only saves time and labor, it simplifies the analysis of customers' usage, allowing load management optimization and less reliance on purchased energy. Wireless industrial process control—including factory networks, RFID tracking and worker communications—can boost productivity, improve quality and save a lot of time when the plant floor needs reconfiguration. Wireless building controls are easier to install than big cable bundles, and allow easy optimization of environmental systems, access control and security monitoring.

Perhaps there are new ideas that can help with monitoring and rebuilding portions of this country's infrastructure, such as those bridges

that have been in the news lately. Surveying and construction aids, imaging systems, sensor networks and flexible job site communications will all be part of that work.

At home, low cost wireless has many ways to help us get more things done, entertain us, or just make life a little easier to cope with. Whether its adding a doorbell at the back door, creating a home computer network, or monitoring the temperature in the garage, wireless technology makes it easy. In the entertainment realm, digital TV is a giant step forward in picture quality and digital radio is just getting started. (I might note that a 32-inch digital TV set now costs about the same as a 21-inch color TV set from the 1960s—*without* adjustment for inflation!)

The technology we work with has opportunities for all economic conditions. The point I'm trying to make is that today's business targets should emphasize applications that have the most value for cost and time savings, convenience, efficiency, quality and flexibility. Of course, these are good things to pursue at any time!

When the economic wave rises again, be prepared to meet the demand (and offer clever new ideas) for services and features that are more fun and interesting. When we all have a few extra discretionary dollars to spend, great wireless products should be high on the list.

Some "Well-Grounded" Reader Feedback

Last month's tutorial article on power and ground received some thoughtful reader feedback. One comment was that single-point grounding was effective only at low frequencies, e.g., audio, and that multiple ground connections—often very many—were a more likely scenario for effective RF grounding. I agree, and those notes are a good addition to the article. Another reader suggested that the topic be extended to grounding outside the equipment, for safety, lightning protection and as a path for conducted and radiated EMI/RFI into or out of the device. While this was beyond the circuit-level emphasis of the article, it is an excellent suggestion.

Another follow-up suggestion was for an article devoted to the "defected ground" structures that were briefly noted. We will keep these topics in mind as we recruit future authors. Thanks for the phone calls and e-mails with your comments and suggestions.

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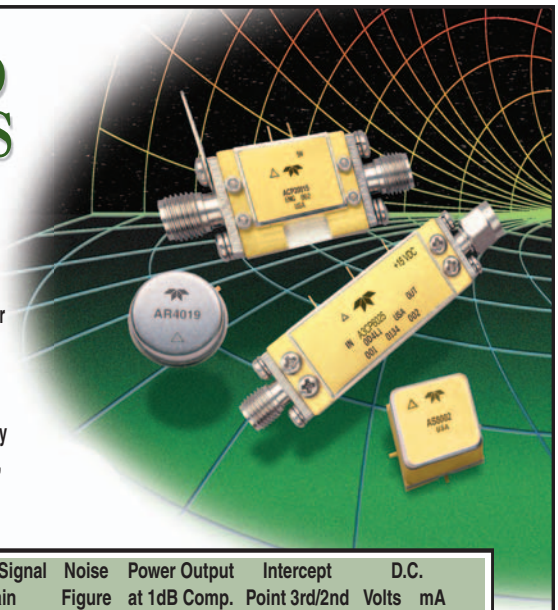

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AC3057	10-3000	11.0	3.8	20.0	32/43	5	95
AR3569	100-3500	17.5	5.2	27.5	36/44	15	275
AR4019	10-4000	16.0	5.0	21.8	34/55	15	200
AC4079	100-4000	8.3	4.8	22.0	35/55	15	115
AS5002	300-5000	21.0	2.2	16.0	25/32	15	88
AS6045	10-6000	14.0	5.0	19.0	30/48	20	140
A3CP6025	10-6000	24.0	4.5	25.0	34/54	15	300
AS8002	100-8000	19.5	2.5	15.5	28/39	15	92
ACP14021	6000-14000	10.3	3.8	25.0	33/50	12	117
ACP20015	2000-20000	10.0	4.5	16.0	26/29	5	76

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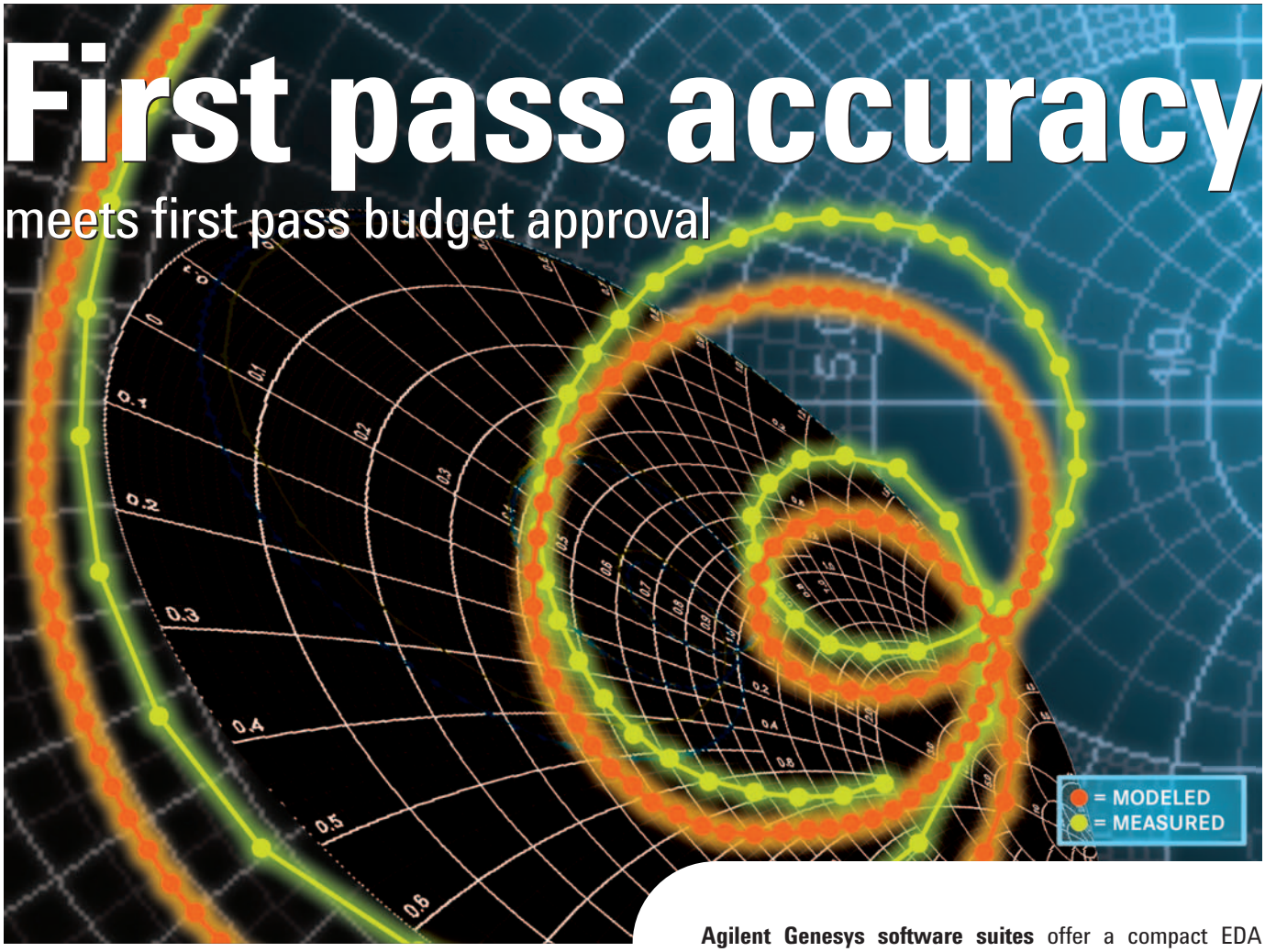

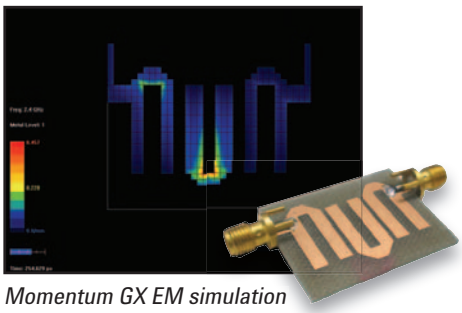

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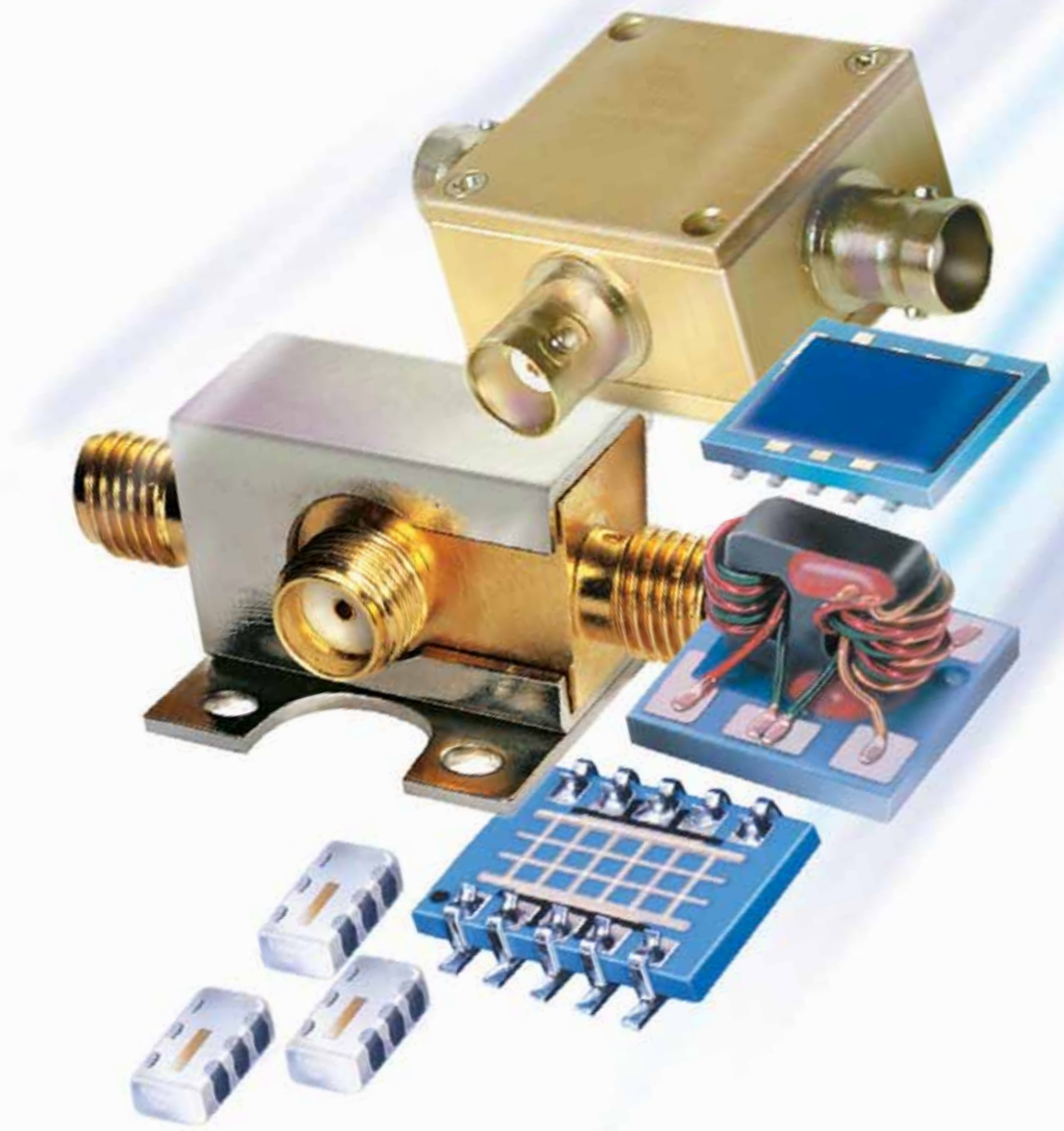

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RF/IF MICROWAVE COMPONENTS

396 Rev E

Business News

Laird Technologies, Inc. announced its acquisition of **Ezurio, Ltd.**, a privately-held company and leading supplier of short range wireless M2M (Machine-to-Machine) solutions. Ezurio's sales revenues in the 12 months ending December 31, 2007, were approximately $8 million. Ezurio is a supplier of Bluetooth and 802.11 (WiFi) embedded RF modules, as well as M2M solutions for wireless data communication applications serving the retail, automotive, healthcare, and other market segments including EPOS (Electronic Point of Sale).

TriQuint Semiconductor® announced that it is a key supplier of dual-band WiFi front-end modules (FEMs) being used by a major chip manufacturer. The modules support the customer's next-generation multiple-input, multiple-output (MIMO) 802.11n wireless connectivity. TriQuint's RF modules achieve new performance, distance and integration milestones, enabling significantly faster wireless connections and increased distance for consumers, as well as system design efficiencies for device vendors.

The **WiMAX Forum** announced that 28 Mobile WiMAX products in the 2.3 GHz and 2.5 GHz frequency bands have been submitted for WiMAX Forum certification since WiMAX Forum labs began accepting applications from vendors in late 2007. The organization further announced its official decision in support of significant market demand to expand the WiMAX Forum product development roadmap for Mobile WiMAX certification in the 700 MHz frequency band.

Tyco Electronics announced it has received a $2 million contract award from **Raytheon Missile Systems** to produce products for Raytheon's precision-guided, long-range Excalibur artillery projectile. Tyco Electronics will produce M/A-COM telemetry transmitter modules, Global Positioning System (GPS) antennas and telemetry antennas to support Excalibur and contribute to the projectile's accuracy in both urban and complex terrain and reduce collateral damage. Raytheon's Excalibur is currently the only precision long-range weapon immediately responsive to the Brigade Combat Team.

Richardson Electronics, Ltd. announced it has signed a global distribution agreement with **Crystek Corporation**, of Fort Myers, FL, to distribute its High Performance Frequency Line. Crystek's products provide high performance frequency solutions needed in advanced applications, including cellular base stations, broadband communication infrastructure, military defense systems and industrial instrumentation equipment. **Richardson Electronics, Ltd.** also announced it has signed a North American distribution agreement with **EPCOS**, a global manufacturer of electronic components, modules and systems. EPCOS offers a broad portfolio of capacitors, thermistors, varistors, surge arrestors, inductors, ferrites and SAW filters, which will enhance Richardson's ability to satisfy the varied and constantly changing needs of its global power conversion customers. Finally, **Richardson Electronics, Ltd.** announced it has signed a global partnership agreement with **Kenet Incorporated** to distribute its entire product line of low-power, high-performance Analog-to-Digital Converters (ADCs). Kenet's products provide the low-power, high performance conversion needed in advanced applications, including cellular base stations, broadband communication infrastructure, military defense systems and industrial instrumentation equipment.

Agilent Technologies Inc. announced that the **Telecommunications Technology Association** (TTA)—Asia's leading test and certification institution—awarded Agilent a contract for Mobile WiMAX Protocol Conformance Test (PCT). TTA provides Mobile WiMAX testing and certification services to the international community and will employ Agilent's N6430A Mobile WiMAX PCT and development system in its base and mobile station test solution.

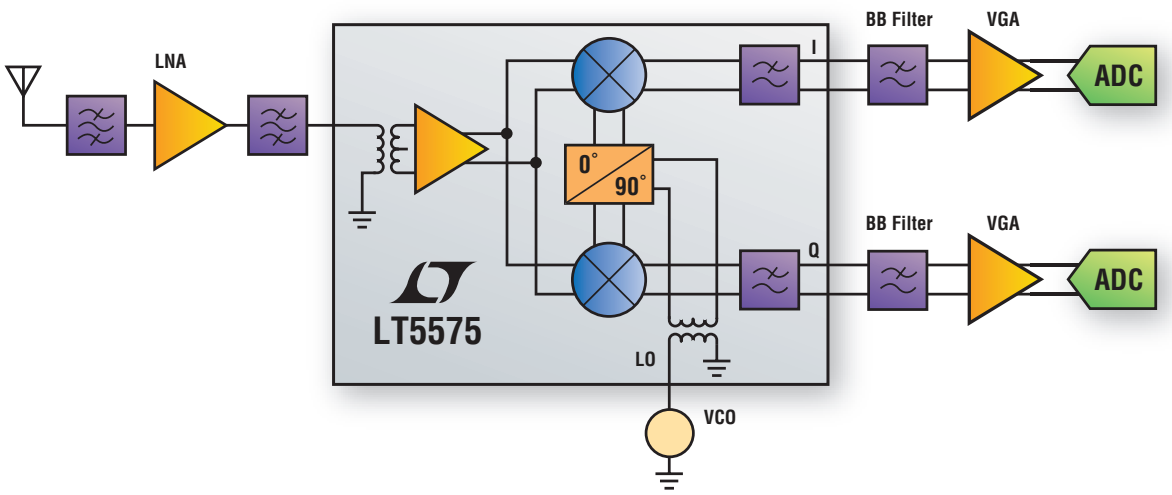
LPKF Laser & Electronics moved offices as of Friday, February 25, 2008. The new address is: 12555 SW Leveton Dr., Tualatin, OR 97062. Other contact information is still the same: Tel. (503) 454-4200; Fax. (503)682-7151; e-mail: info@lpkfusa.com; and Web: http://www.lpkfusa.com.

Weintraub Telecomm, LLC announced that it has signed a Letter of Intent to acquire the business of **Jensen Communications Corp.** The transaction, projected to close in the first quarter of 2008, is subject to the completion of a definitive purchase agreement between the companies.

Space Data Corporation has entered into a joint venture that, when approved by the FCC, will consolidate its leadership position in the Narrowband PCS (NPCS) part of the licensed 900 MHz band. Space Data will be the licensee of nearly 2 MHz of the 3 MHz allocated to NPCS by the FCC. As part of a series of spectrum swaps leading to this consolidation, Space Data is forming a Joint Venture with **Scott MacIntyre**, a wireless entrepreneur, that will encompass 200 kHz of spectrum that is non-core to its planned SkySite® operations and will be available for lease or sale. This spectrum is ideal for such applications as private SMR (Specialized Mobile Radio) networks for industrial customers requiring priority communications during crises. It also has potential low-cost applications for new services such as nationwide distribution of iPOD or gaming content, meter reading and other narrowband applications needing a nationwide footprint without spending billions on spectrum.

Mouser Electronics, Inc. announced it has signed a global catalog and internet sales channel partnership agreement with **WJ Communications**. According to the sales channel agreement, Mouser will stock RF ampli-

28dBm IIP3 Direct Conversion I/Q Demodulator



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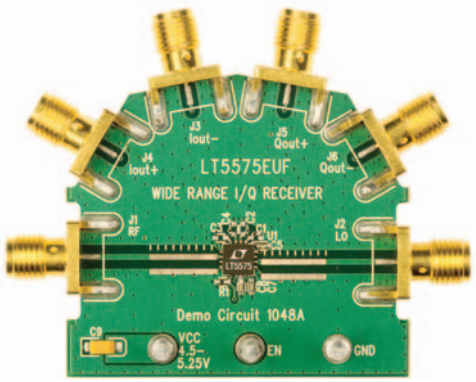

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LINEAR TECHNOLOGY

fiers, mixers, and frequency converters. **Mouser Electronics, Inc.** also announced it will distribute an extensive selection of semiconductors from **Infineon Technologies**. Mouser will stock a variety of Infineon's products including microcontrollers, power management and circuit protection products, as well as discrete semiconductors, general purpose ICs, and silicon RF transistors. Finally, **Mouser Electronics, Inc.** announced it has signed a distribution agreement with **Dielectric Laboratories**. Key products for Dielectric Laboratories include High Q multi-layer capacitors (MLC) and broadband DC blocks. The distribution agreement with Dielectric Laboratories capitalizes on Mouser's core competencies of fast introduction, extensive stocking, and promotion of the newest products to the design engineering community.

Planar Monolithics Industries announces its merger with **Planar Electronics Technology** and **Planar Filter Company**. The synergy between these three Frederick, Maryland, based corporations enables the offering of upgraded hybrid MIC/MMIC RF and microwave components, subsystems, and systems to their customers as well as enhancing their ability to support major military and defense contractors.

Skyworks Solutions, Inc. announced that it is increasing business at **LG Electronics** by virtue of strong demand for its suite of front-end solutions coupled with several strategic design wins. In particular, Skyworks is at the heart of several of LG's recently introduced models including the LG-KF700, LG-KF600, LG-KF610 and LG-KF510.

Technology News

Broadcast television could reap an additional $2 billion in annual revenue by 2012 delivering content to mobile and handheld devices if an industry standard is adopted and technology deployed quickly, according to a study commissioned and released by the NAB technology advocacy program known as FASTROAD (Flexible Advanced Services for Television & Radio On All Devices). The report concludes that the success of new mobile and handheld (M/H) DTV services in the U.S. will be maximized if an industry-accepted Advanced Television Standards Committee standard for M/H DTV is released by early 2009 and universally adopted for M/H broadcasting. Delaying adoption of the standard will dramatically impact the revenue potential for both local and network broadcasters in a negative way, the report concludes. The report, titled "Study of the Impact of Multiple Systems for Mobile/Handheld Digital Television," was authored by experts from BIA Financial Network with support from Law and Economics Consulting Group (LECG).

People in the News

Acceleware Corp. is pleased to announce the appointment of **Shawn Lorenz** as the Vice President of Sales for the corporation. With over 25 years of experience in the high tech industry, Lorenz will be responsible for growing the organization's global sales initiatives for Acceleware's acceleration solutions. Lorenz brings with him a proven track record of increasing revenues as well as developing, implementing and managing effective sales strategies. Previous to joining Acceleware, Shawn Lorenz held executive and director level positions with several successful companies such as EMC / Documentum, Gigaspaces, and Verity.

Phase Matrix has appointed **Dr. Alexander Chenakin** to Director, Frequency Synthesis Group. Dr. Chenakin is responsible for overseeing the development of a new generation of fast switching frequency synthesizers. Dr. Chenakin is an internationally recognized expert in the field of microwave frequency synthesis. He has received his degree from Kiev Polytechnic Institute and has worked in a variety of technical and managerial positions around the world. He has led the development of advanced products for Celeritek, Nextek, Micro Lambda Wireless, General Electronic Devices, and other companies. His professional achievements have been widely presented in professional magazines and international conferences.

Aeroflex/KDI-Integrated Products announces the appointment and promotion of **Dr. Chandra Gupta PhD** to the position of General Manager. Chandra joined the KDI-Integrated Products team in 2003, in the role of Vice President of Engineering. Prior to joining KDI-Integrated Products, Chandra has over 30 years experience in the design and development and manufacturing of Micro and Millimeter wave components and systems with companies such as Herley-MDI, BAE Systems, Millitech, Alpha Industries and M/A Com. Chandra received his PhD in Electronic Engineering from the University of Wales, United Kingdom, and has earned his MBA from Rutgers Business School. Chandra's first tasks in his new role will be to implement a "COTS" program for their catalog products.

Sales Appointments

RFMW, Ltd. welcomes its newest employee, **Cristina Larrazabal,** to its Southern California sales team. Cristina will take on the field sales management of the Company's San Diego and Orange County territories. Cristina comes from a long career in electronics distribution, (as inside and field sales) having spent 4 1/2 years with Newark Electronics and most recently, more than 8 years with Future Electronics.

MU-DEL Electronics, Inc. has just signed two new representatives to market their products. MU-DEL manufactures high technology RF equipment. **Kelley Systems Company** will be supporting MU-DEL in Alabama, Tennessee and Mississippi. KSC is located in Lake Guntersville, AL and their phone number is 256-582-8677. **Tech Marketing Associates, Inc.** will be supporting MU-DEL in Northern California and Northern Nevada. TMA is located in Mountain View, CA and their phone number is 408-736-3687 or 650-968-0102.

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RF/IF MICROWAVE COMPONENTS

346 rev N

Desktop Access to Time Around the World — Symmetricom, Inc. has announced the release of SymmTime™ 2008, a free multi-zone desktop time utility. Easy to set up and use, SymmTime 2008 automatically synchronizes your system clock through the Internet to any accessible Network Time Protocol (NTP) server and incorporates updated daylight saving schedules of every country. Providing easy, desktop access to time around the world, SymmTime 2008 is available for immediate download at: http://www.ntp-systems.com/symmtime.asp.

Features of the new SymmTime version include: New clock faces, including 15 analog clock faces and 14 digital clock faces; Dual screen support; Expanded clock sizes; plus Windows® Vista® compatibility. SymmTime 2008 is free, and the company assures users that this program does not contain any spyware or data mining software.

Modules Allow Button-Cell Powered RF Links — Nordic Semiconductor ASA (www.nordicsemi.com) has announced that designers without specialized RF knowledge can now build an Ultra-Low Power (ULP) ISM-band wireless link into a product or application within hours by using pre-approved modules developed by U.S. RF specialist, RF Digital (www.rfdigital.com). Because all the RF development work has been done, the modules only require a digital In/Out, power (+V) and ground (GND) connection. The modules are designed to work in almost any operating environment or product design—with the exception of sealed metal enclosures which the laws of physics dictate will act as an electromagnetic shield to RF. This makes the modules particularly attractive to product designers that may be new to wireless. By using these modules, they do not need to immediately get involved with the RF circuitry when investigating wireless applications and developing proof-of-concept prototypes.

Seven radio-only modules based on existing Nordic transceivers are being offered. The modules are based on the Nordic "E" transceivers (nRF24E1 and nRF9E5) and include on-board EEPROMs. RF Digital has developed six off-the-shelf application modules ready for instant drop-in. All application modules are FCC and IC-approved with no further approvals required. European CE approval is expected shortly.

Royalty-Free Infrared Wireless Communication Protocol — Vishay Intertechnology, Inc. continues to broaden its optoelectronics portfolio with the release of Courier-115™ a royalty-free wireless software protocol for devices that are based on the Texas Instruments (TI) ultra-low power MSP430 microcontroller (MCU) platform. Targeting the data logger, personal biometer, and industrial metering markets, Courier-115 provides the basis for simple and fast infrared communication supporting data rates up to 115 kbit/s. Courier-115 and any of Vishay's infrared transceivers enable extremely low-cost, proprietary wireless communication in products like glucose meters or water meters.

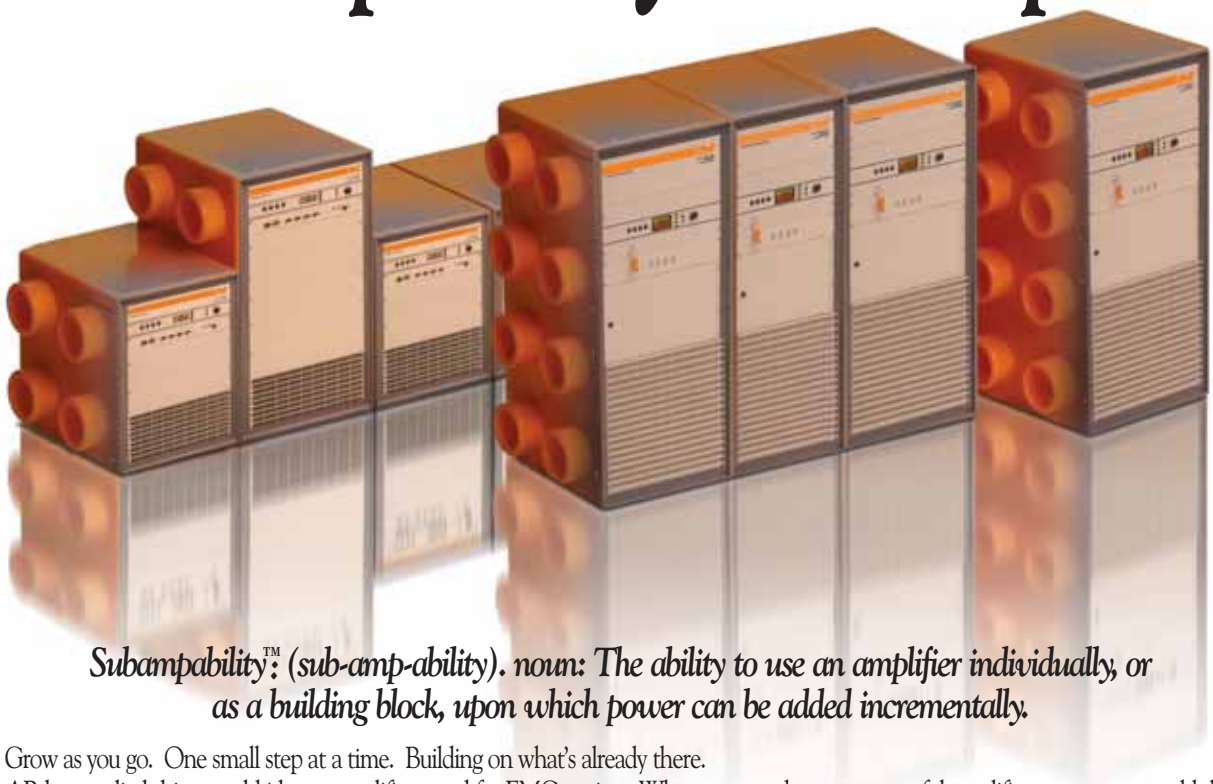
Radio frequency (RF) and infrared communication technology co-exist in a number of metering applications, but infrared provides a more convenient means for high-volume device calibration, initialization and launch in a manufacturing environment. While RF commonly serves to allow wireless meter reading in the field, infrared is a much faster medium for downloading firmware updates. The low cost of infrared communication helps manufacturers fill these critical application gaps.

As a member of the Texas Instruments Developer Network, Vishay developed the Courier-115 software based on the MSP430 MCU. The combination of the MSP430 MCU's extremely low-power standby current with an instant-on active mode and fully synchronized, high-speed system clock enables the development of smaller, lower-cost applications. Vishay's Courier-115 complements this low power consumption with a unique wake-up-listen-sleep routine, resulting in an average current of 1.0 µA. Further information on the Courier-115 can be downloaded from the Vishay Web site: www.vishay.com/docs/49715/courier.pdf.

Process Characterization at Sub-65 nm — Keithley Instruments, Inc. announces a partnership with Stratosphere Solutions, Inc. (www.stratosol.com), a provider of innovative parametric yield improvement solutions for integrated circuit manufacturers. Keithley's partnership with Stratosphere Solutions will address advanced process development and monitoring using an Array TEG (test element group) technology. Parametric process variation at the sub-65 nm level is posing significant challenges to design and test engineers as IC manufacturers seek to produce ever-smaller devices. The semiconductor industry is seeing a rapidly growing need for monitoring extremely sensitive production processes in order to optimize IC performance without sacrificing yields. Keithley and Stratosphere Solutions will work together to provide mutual customers with a unique characterization infrastructure that includes high volume, high throughput, and reliable parametric measurements using Keithley's Series S600 Parametric Testers and StratoPro™ IP.

Keithley's Series S600 Parametric Testers help fabs and wafer foundries reduce their cost of test by being adaptable to changing device technologies. Their ability to be repurposed as very minimal cost DC, RF, and array TEG testers provides capital equipment reuse, lowering the cost of test. The latest in the Series S600, the Model S680, combines, in a single test system, parallel testing capability, high DC sensitivity, femtoamp-level resolution and RF *S*-parameter measurements up to 40 GHz. Information is available at www.keithley.com/products/semiconductor.

Here's The Idea Behind Our Subampability™ Concepts!



Subampability™: (sub-amp-ability). noun: The ability to use an amplifier individually, or as a building block, upon which power can be added incrementally.

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Once this initial upgrade is performed, the sky's the limit. The 20S4G11A and the 35S4G8A are like building blocks that can easily be expanded by adding sub amps and controller/combiner units.

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Power Combiners, Impedance Transformers and Directional Couplers: Part IV

By Andrei Grebennikov

This series of articles concludes with an examination of directional couplers. Readers are reminded that all four parts can be downloaded from our Web site.

Coupled-Line Directional Couplers

The first directional couplers consisted of either a two-wire balanced line coupled to a second balanced line along a distance of quarter wavelength, or a pair of rods a quarter wavelength long between ground planes [53]. Although the propagation of waves on systems of parallel conductors was investigated many decades ago—in connection with the problem of crosstalk between open wire lines or cable pairs in order to eliminate the natural coupling rather than use it—the first exact design theory for TEM (transverse electromagnetic) transmission-line couplers was introduced by Oliver [74].

In terms of the even and odd electric-field modes describing a system of the coupled conductors, it can be stated that the coupling is backward with the coupled wave on the secondary line propagating in the direction opposite to the direction of the wave on the primary line, the directivity will be perfect with *VSWR* equal to unity if $Z_0^2 = Z_{0e}Z_{0o}$ at all cross sections along the directional coupler, and the midband voltage coupling coefficient C of the directional coupler is defined as

$$C = \frac{Z_{0e} - Z_{0o}}{Z_{0e} + Z_{0o}} \tag{48}$$

A coupled-line directional coupler, the stripline single-section topology of which is shown in Figure 40(a), can be used for broadband power division or combining. Its electrical properties are described using a concept of two types of excitations for the coupled lines in TEM approximation. In this case, for the even mode, the currents flowing in the strip conductors are equal in amplitude and flow in the same direction. The electric field has even symmetry about the center line, and no current flows between the two strip conductors. For the odd mode, the currents flowing in the strip conductors are equal in amplitude, but flow in opposite directions. The electric field lines have an odd symmetry about the center line, and a voltage null exists between these two strip conductors. An arbitrary excitation of the coupled lines can always be treated as a superposition of appropriate amplitudes of even and odd modes. Therefore, the characteristic impedance for even excitation mode Z_{0e} and the characteristic impedance for the odd excitation mode Z_{0o} characterize the coupled lines. When the two coupled equal-length strip lines are used in a standard system with characteristic impedance of Z_0, $Z_0^2 = Z_{0e}Z_{0o}$ and

$$Z_{0e} = Z_0\sqrt{\frac{1+C}{1-C}} \tag{49}$$

$$Z_{0o} = Z_0\sqrt{\frac{1-C}{1+C}} \tag{50}$$

An analysis in terms of scattering S-parameters gives $S_{11} = S_{14} = 0$ for any electrical lengths of the coupled lines and the output port 4 is isolated from the matched input port 1. Changing the coupling between the lines and their widths can change the characteristic impedances Z_{0e} and Z_{0o}. In this case,

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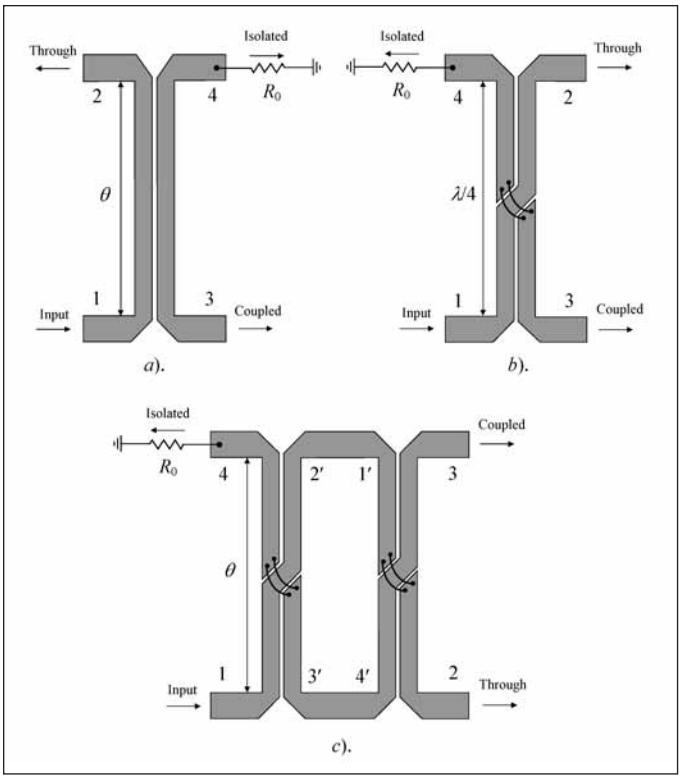

Figure 40 · Coupled-line directional couplers.

$$S_{12} = \frac{\sqrt{1-C^2}}{\sqrt{1-C^2}\cos\theta + j\sin\theta} \tag{51}$$

$$S_{13} = \frac{jC\sin\theta}{\sqrt{1-C^2}\cos\theta + j\sin\theta} \tag{52}$$

where θ is the electrical length of the coupled-line section.

The voltage-split ratio K is defined as the ratio between voltages at port 2 and port 3 by

$$K = \left|\frac{S_{12}}{S_{13}}\right| = \frac{\sqrt{1-C^2}}{C\sin\theta} \tag{53}$$

where K can be controlled by changing the coupling coefficient C and electrical length θ.

For a quarter-wavelength-long coupler when $\theta = 90°$, Eqs. (51) and (52) reduce to

$$S_{12} = -j\sqrt{1-C^2} \tag{54}$$

$$S_{13} = C \tag{55}$$

from which it follows that equal voltage split between the output ports 2 and 3 can be provided with

$$C = 1/\sqrt{2}$$

If it is necessary to provide the output ports 2 and 3 at one side, it is best to use a construction of a microstrip directional coupler with crossed bondwires, as shown in Figure 40(b). The strip crossover for a stripline directional coupler can be easily achieved with the three-layer sandwich. A microstrip 3-dB directional coupler fabricated on alumina substrate for idealized zero strip thickness should have the calculated strip spacing of less than 10 µm. Such a narrow value easily explains the great interest in the construction of directional couplers with larger spacing. The effective solution is to use a tandem connection of the two identical directional couplers, which alleviates the physical problem of tight coupling, since two individual couplers need only 8.34-dB coupling to achieve a 3-dB coupler [75, 76]. The tandem coupler shown in Figure 40(c) has the electrical properties of the individual coupler when the output ports 1, 4 and 2, 3 are isolated in pairs, and the phase difference between the output ports 2 and 3 is of 90°.

From an analysis of the signal propagation from input port 1 to output ports 2 and 3 of the tandem coupler, when the signal from the input port 1 propagates to the output port 2 through the traces 1-2′-1′-2 and 1-3′-4′-2 while the signal flowing through the traces 1-2′-1′-3 and 1-3′-4′-3 is delivered to the output port 3, the ratio of the scattering parameters and S_{12}^T and S_{13}^T of a tandem coupler can be expressed through the corresponding scattering parameters S_{12} and S_{13} of the individual coupler as

$$\frac{S_{12}^T}{S_{13}^T} = \frac{S_{12}^2 + S_{13}^2}{2S_{12}S_{13}} = -j\frac{1-C^2\left(1+\sin^2\theta\right)}{2C\sqrt{1-C^2}\sin\theta} \tag{56}$$

As a result, the signal at the port 2 overtakes the signal at the port 3 by 90°. In this case, for a 3-dB tandem coupler with $\theta = 90°$, the magnitude of Eq. (56) must be equal to unity. Consequently, the required voltage coupling coefficient is calculated as

$$C = 0.5\sqrt{2-\sqrt{2}} = 0.3827$$

or

$$C_{12} = C_{13} = 8.34 \text{ dB}$$

As an example, a tandem 8.34-dB directional coupler has the dimensions of $W/h = 0.77$ and $S/h = 0.18$ for alumina substrate with $\varepsilon_r = 9.6$, where W is the strip width, S is the strip spacing and h is the substrate thickness [56].

Another way to increase the coupling between the two edge-coupled microstrip lines is to use several parallel narrow microstrip lines interconnected with each other by the bondwires, as shown in Figure 41. For a Lange coupler shown in Figure 41(a), four coupled microstrip lines

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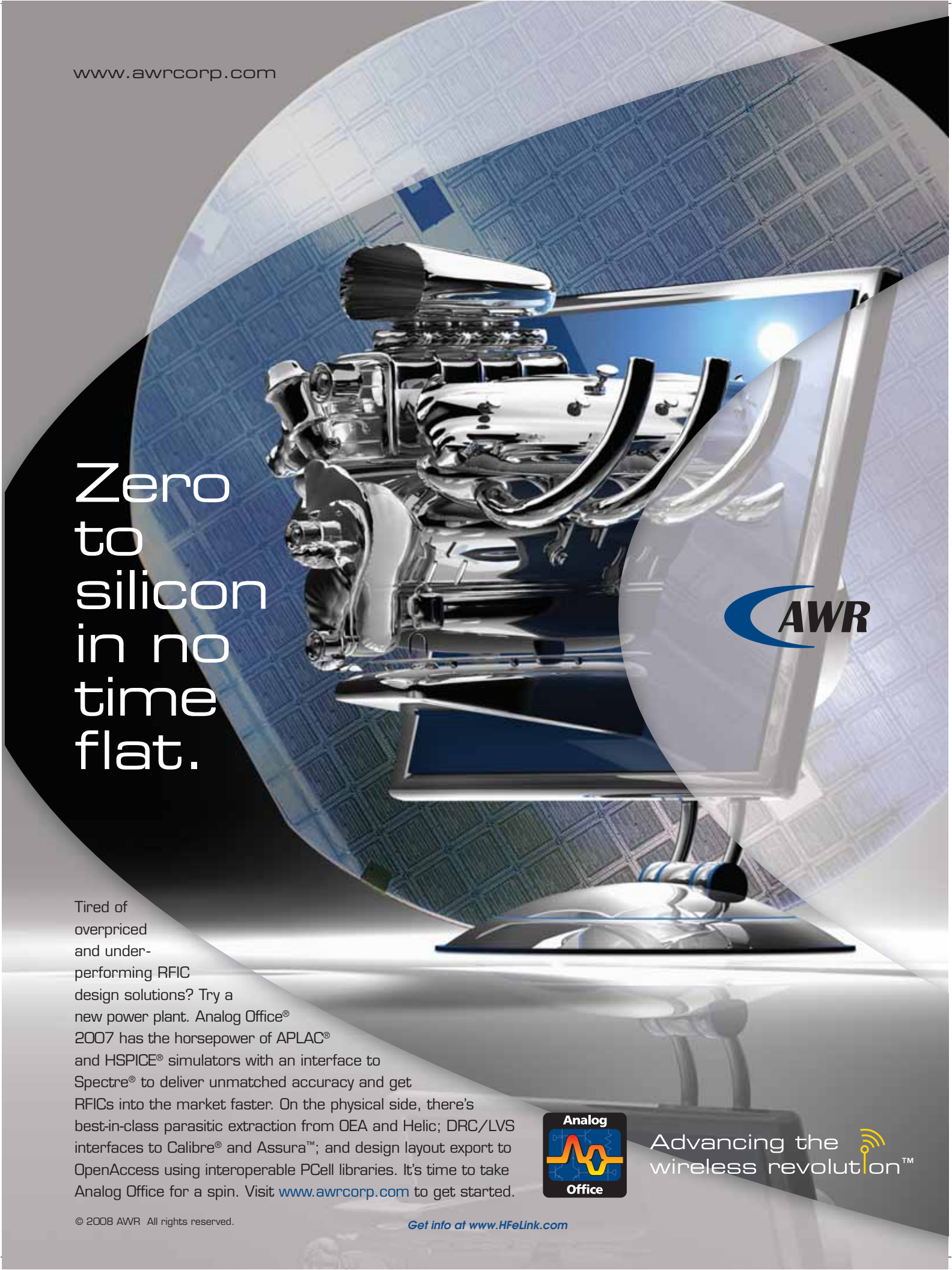

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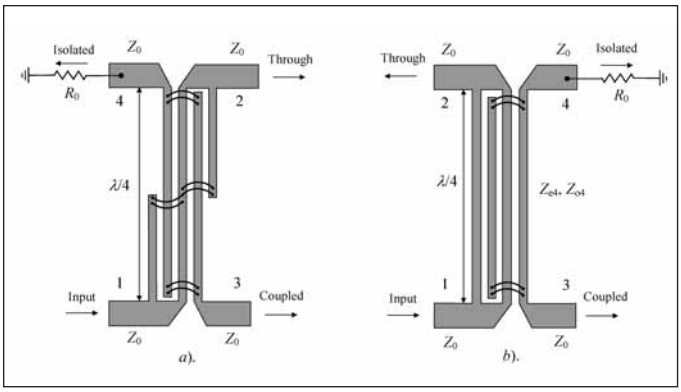

Figure 41 · Lange directional couplers: (a) original interdigital configuration, and (b) "unfolded" version.

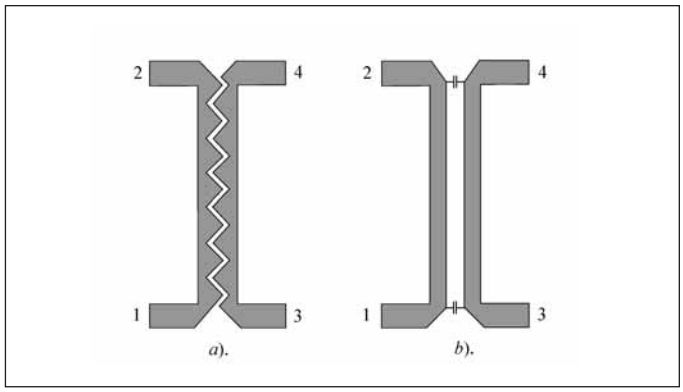

Figure 42 · Coupled-line directional couplers with compensation for directivity vs. frequency.

are used, achieving a 3-dB coupling over an octave or more bandwidth [77]. In this case, the signal flowing to the input port 1 is distributed between the output ports 2 and 3 with the phase difference of 90°. However, this structure is quite complicated for practical implementation when, for alumina substrate with $\varepsilon_r = 9.6$, the dimensions of a 3-dB Lange coupler are $W/h = 0.107$ and $S/h = 0.071$, where W is the width of each strip and S is the spacing between adjacent strips.

Figure 41(b) shows the unfolded Lange coupler with four strips of equal length; it offers the same electrical performance but is easier for circuit modeling [78]. The even-mode characteristic impedance Z_{e4} and odd-mode characteristic impedance Z_{o4} of the Lange coupler with $Z_0^2 = Z_{e4}Z_{o4}$ in terms of the characteristic impedances of a two-conductor line (which is identical to any pair of adjacent lines in the coupler) can be obtained by

$$Z_{e4} = \frac{Z_{0o} + Z_{0e}}{3Z_{0o} + Z_{0e}} Z_{0e} \tag{57}$$

$$Z_{o4} = \frac{Z_{0e} + Z_{0o}}{3Z_{0e} + Z_{0o}} Z_{0o} \tag{58}$$

where Z_{0e} and Z_{0o} are the even- and odd-mode characteristic impedances of the two-conductor pair [79].

The midband voltage coupling coefficient C is given by

$$C = \frac{Z_{e4} - Z_{o4}}{Z_{e4} + Z_{04}} = \frac{3\left(Z_{0e}^2 - Z_{0o}^2\right)}{3\left(Z_{0e}^2 - Z_{0o}^2\right) + 2Z_{0e}Z_{0o}} \tag{59}$$

The even- and odd-mode characteristic impedances Z_{0e} and Z_{0o}, as functions of the characteristic impedance Z_0 and coupling coefficient C, are determined by

$$Z_{0e} = Z_0\sqrt{\frac{1+C}{1-C}}\,\frac{4C - 3 + \sqrt{9 - 8C^2}}{2C} \tag{60}$$

$$Z_{0o} = Z_0\sqrt{\frac{1-C}{1+C}}\,\frac{4C + 3 - \sqrt{9 - 8C^2}}{2C} \tag{61}$$

For alumina substrate with $\varepsilon_r = 9.6$, the dimensions of such a 3-dB unfolded Lange coupler are $W/h = 0.112$ and $S/h = 0.08$, where W is the width of each strip and S is the spacing between the strips.

The design theory for TEM transmission-line couplers is based on an assumption of the same phase velocities of the even and odd propagation mode. However, this is not the case for coupled microstrip lines, since they have unequal even- and odd-mode phase velocities. In this case, the odd mode has more fringing electric field in the air region, but with the even mode, the electric field is concentrated mostly in the substrate under the microstrip lines. As a result, the effective dielectric permittivity in the latter case is higher, thus indicating a smaller phase velocity for the even mode. Consequently, it is necessary to apply phase velocity compensation techniques to improve coupler directivity, which decreases with increasing frequency. Figure 42(a) shows a typical wiggly-line coupler (with sawtooth shape of coupled lines), which increases the physical lengths of the adjacent edges of the microstrip lines. This slows the odd-mode wave with little affect on the even-mode wave [80].

High directivity can also be achieved by using capacitive compensation. Figure 42(b) shows the capacitively compensated microstrip directional coupler where two identical lumped capacitors are connected between the coupled lines at their edges. Physically, these edge capacitors affect the odd mode by equivalent extension of the transmission-line electrical lengths, with almost no effect on even mode. For an ideal lossless operation condition at 12 GHz using standard alumina substrate, the compensated coupled-line microstrip directional coupler can improve directivity from 13.25 dB to infinity [81]. Capacitive compensation can also be performed by a gap

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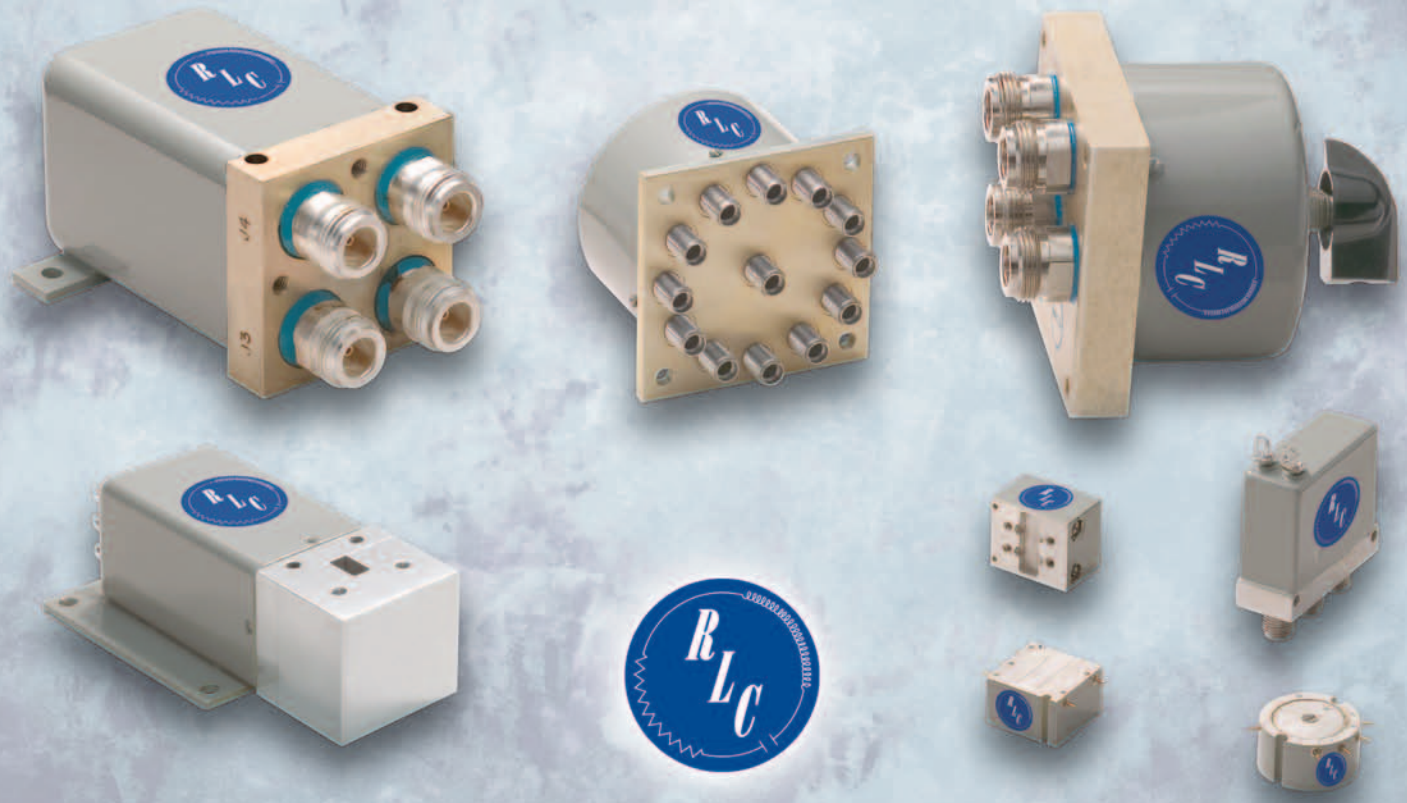

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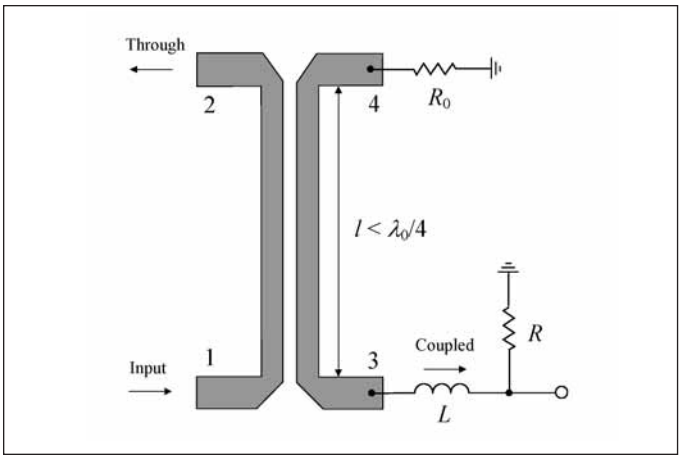

Figure 43 · Coupled-line directional coupler with reduced-size and frequency compensation.

coupling of the open-circuit stub formed in a stub-coupled line [82]. In this case, the coupler directivity can be improved by 23 dB in a frequency range from 1 to 2.5 GHz compared to the directivity of the conventional uncompensated microstrip coupler.

At radio frequencies and low microwaves, the conventional quarter-wavelength directional coupler has very large dimensions that limit their practical application especially in monolithic circuits. Figure 43 shows a reduce-size directional coupler consisting of the two coupled microstrip lines, the electrical lengths of which are much smaller than quarter wavelength. The main problem of the coupler at frequencies where the electrical length of its coupled lines is smaller than quarter wavelength, is that the degree of coupling linearly varies with frequency. To compensate this frequency behavior, the output port 3 can be connected to a series inductor L followed by a shunt resistor R [36, 83]. The inductance value depends on the coupling value and flatness, and midband frequency, while the resistance value depends on the impedance of the secondary line and inductance value. Such a microstrip reduced-size directional coupler with L = 180 nH and R = 62 Ω can provide the coupling of about 30 dB with flatness of ±0.1 dB, directivity greater than 20 dB, insertion loss less than 0.25 dB, and *VSWR* less than 1.15 in a frequency bandwidth of 60% around 200 MHz. Tuning of the center bandwidth frequency and coupling can be simply realized by varying the inductance value.

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Author Information

Andrei Grebennikov received his Dipl. Ing. degree in radio electronics from Moscow Institute of Physics and Technology and PhD degree in radio engineering from Moscow Technical University of Communications and Informatics in 1980 and 1991, respectively. He has extensive academic and industrial experience working with Moscow Technical University of Communications and Informatics, Russia, Institute of Microelectronics, Singapore, M/A-COM, Ireland, and Infineon Technologies, Germany and Austria, as an engineer, researcher, lecturer, and educator. He read lectures as a Guest Professor in University of Linz, Austria, and presented short courses and tutorials as an Invited Speaker at International Microwave Symposium, European and Asia-Pacific Microwave Conferences, and Motorola Design Centre, Malaysia. He is an author of more than 70 papers, 3 books and several European and US patents. He can be reached by grandrei@ieee.org.

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Recent Updates in Connector and Cable Technology

Interconnections are an integral part of all electronic circuits and systems. Their importance requires us to periodically stop and evaluate new developments in this part of our technology. Whether for RF, microwave, optical, or high speed digital applications, there is always progress to report. Here are notes on some of the recent trends in connectors and cables.

High Speed Digital Interconnections

In recent months, the cable and connector industry has announced many new products that incorporate advances in signal integrity performance, mechanical design and installation or assembly. This reflects recent trends for increased digital content in electronic equipment, as well as higher clock speeds.

Tyco Electronics recently announced their new Z-PACK TinMan connector as a cost-effective solution for high-performance backplane interconnect systems to 12.5 Gb/s. The connector has successfully demonstrated 10 gigabit data streams performance across the backplane compliant to 10Gbase-KR electrical requirements. Ground contacts positioned within each pin header column, combined with unique contact lead frame arrangements and a receptacle side ground shield, enable the connector to achieve low crosstalk and high through-put performance levels.

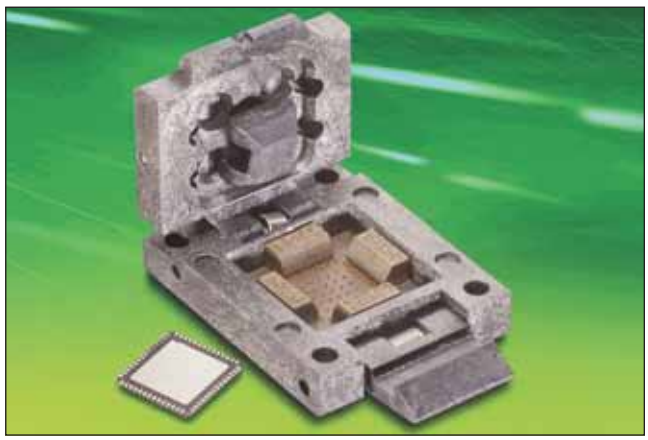
FCI has developed their AirMax VS® 3-pair backplane connector system that meets the mid-plane connector interface requirements defined in the recently-announced Storage Bridge Bay (SBB), Version 2.0 specification. AirMax VS system uses edge-coupling technology and an air dielectric between adjacent conductors to deliver high signal density with low insertion loss and low crosstalk, all without the use of costly and space-consuming metal shields. The connector system will handle differential signals to 12.5 Gb/s.

Other companies have developed high-speed connectors for board-to-board and backplane applications. Design variations include EMI filtered connectors, various pin spacings and interconnect densities, along with header and pin configurations for standard digital bus interfaces.

High-speed digital device testing has also gotten significant attention from connector manufacturers, supporting an increasing number of devices, packages and pin densities.

Samtec has recently introduced its new Spirit™ Connectorless Test Probe (SCTP Series) for high speed serial protocol testing. These probes employ 100-ohm differential pair signal routing, with a patent-pending replaceable compression contact array system on the DUT end. Samtec's high speed Q Strip® connectors are used on the instrument end. For increased reliability and longevity, the probe features a spring-loaded shroud to protect the compression contact tips from damage, while the replaceable contact array extends the life of the probe indefinitely. This connectorless system provides for non-intrusive testing from 1.25 Gbps to 5.2 Gbps and is compatible with the Intel® specific PCI Express® footprint.

Aries Electronics has announced that its entire line of high-frequency center probe test sockets (photo below) can now be used with devices requiring pitches as low as 0.40 mm. The sockets are used in applications such as CSP, MicroBGA, DSP, LGA, SRAM, DRAM and Flash devices with speeds from 1 GHz to more than 10 GHz. The 4-point spring probe crown ensures "scrub" on solder ball oxides for reliable contact mating, and the pointed probe works with LGAs, MLFs and other socket types.



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RF and Microwave Connectors

Recent trends in RF and microwave connectors have focused on refinements for reliable installation. For example, San-tron's new e-SMA connector features an extended ferrule for greater reliability, solder-free captivating center conductor contact, and a solder-damming positive cable stop. SV Microwave's line of SMP bullet connectors cover high frequencies of to DC to 40 GHz. The bullet is designed to allow the joining of two RF Modules by captivating the bullet between the two shrouds. Its push-on design allows the installer to mate connectors without the need for threads or wrenches.

All connector companies have introduced new connectors that accommodate specific customer requirements, including precise interface to specific cable types, greater mating/unmating forces for high reliability, improved self-alignment in blind-mate connectors, plus simpler installation or smaller footprint on p.c. boards.

Interconnecting cable assemblies have also gotten significant recent attention. Test cables and system interconnect cable assemblies feature better mechanical properties and higher reliability, with a wide range of bending radius options. Miniature cables for consumer products are a growing segment of the market, as frequencies increase and signal integrity becomes more important. Applications driving the consumer market include wireless networking equipment, digital television, CATV set top boxes, and many other devices. Often, these applications require interconnection from the p.c. board electronics to an antenna, input connector or output connector.

Optical Cables and Connectors

A few notes on optical technology are appropriate for this report, as well. One of the recent developments is the growth of high definition television. For such applications, Omron has announced its P1TX4C-SX51 Transmitter Optical Subassembly (TOSA) and the P1RX4C-SX51 and Receiver Optical Subassembly (ROSA) to serve the high-definition video market. These products are p.c. board-mounted, with integrated electronics, optics and optical connector. They support long-distance data transfer challenges inherent in the bandwidth-intensive, high-speed data applications associated with HDMI rev1.3 compliant high-definition video and audio formats.

An application area that is in the early stages of development is optical linking from an on-ground equipment housing to tower-mounted wireless base station radios. As MIMO (multiple input, multiple output) technology becomes widely deployed, tower-top equipment will become common. The solutions to the required communication links in an outdoor environment is an important subject for future coverage.

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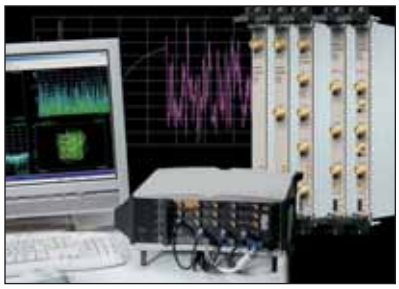

Broadband Digitizers

Agilent Technologies Inc. has announced an upgraded version of its popular 89600 Series Vector Signal Analysis Software (VSA) that will now interface with its Acqiris 10-bit and 12-bit CompactPCI broadband digitizers. The newly released version 8.0 of the Agilent 89601A VSA software provides rapid data transfers from the digitizers to the host, reducing measurement times and maximizing user productivity. The 10-bit digitizers, the DC222, DC252 and DC282, offer a bandwidth of up to 2 GHz and a very large memory of up to 1 GS in single-channel mode. For smaller bandwidth applications requiring 12-bit vertical resolution, Agilent offers the dual-channel DC440 and DC438. Pricing for a 10-bit digitizer starts at $23,710. The starting price for the 12-bit digitizer is $8,200.

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Switches

RF Coaxial Relay

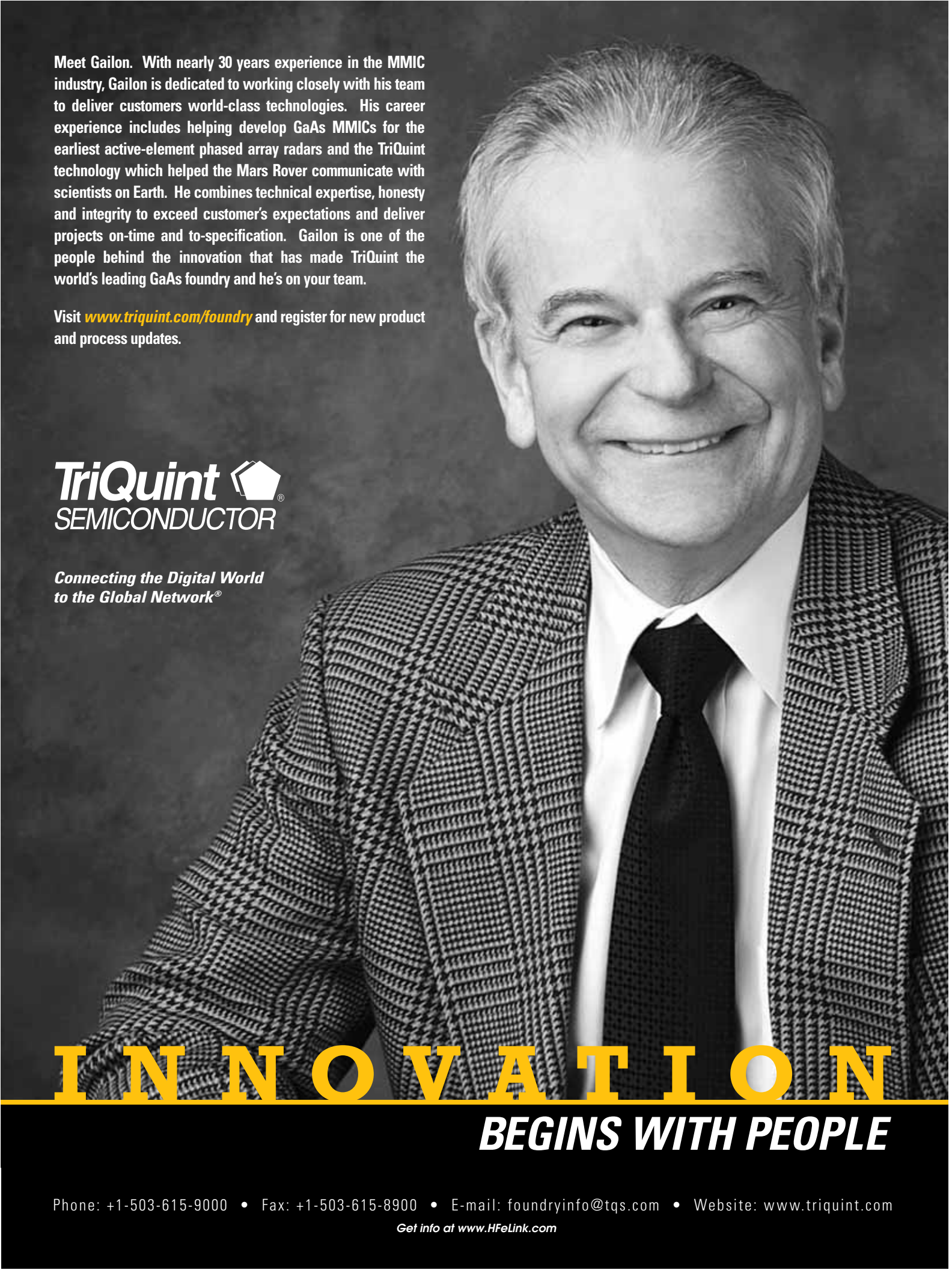
RelComm Technologies, Inc. has complimented its product line by offering a new multi-position 1P8T relay in a smaller package. The RMT Series SMA connectorized relay measures 1.75" sq. × 2.00" tall (excluding connectors). This device provides greater layout and packaging density with exceptional RF performance to 18 GHz. Product is available with up to eight output positions in a failsafe or latching configuration. Options include DC header and TTL logic. A silver plated aluminum housing is also available for reduced insertion loss.

RelComm Technologies, Inc.
www.relcommtech.com

Digital SP10T Switch

MITEQ introduces an absorptive single pole ten throw switch, Model SW10-001145AN3NF. This switch covers the frequency range from 70 MHz to 14.5 GHz with a minimum of 80 dB isolation and maximum VSWR of 2:1. The 10-bit input control word is TTL compatible and commands switching time with settling from 50% to 90% of 2 µs. The power handling capability is 20 dBm. Options available include extended band and sub-band versions covering the entire 70 MHz to 18 GHz range.

MITEQ, Inc.
www.miteq.com


Meet Gailon. With nearly 30 years experience in the MMIC industry, Gailon is dedicated to working closely with his team to deliver customers world-class technologies. His career experience includes helping develop GaAs MMICs for the earliest active-element phased array radars and the TriQuint technology which helped the Mars Rover communicate with scientists on Earth. He combines technical expertise, honesty and integrity to exceed customer's expectations and deliver projects on-time and to-specification. Gailon is one of the people behind the innovation that has made TriQuint the world's leading GaAs foundry and he's on your team.
Visit www.triquint.com/foundry and register for new product and process updates.
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Get info at www.HFeLink.com

Programmable Matrix Assembly

JFW's transceiver test systems are the next generation in RF matrix switch technology. Unlike a traditional matrix switch, the transceiver test system does away with the restrictions of designated inputs and outputs and turns every connection into an input/output. This means that every port in the system is visible to every other port, making the possible number of radio test configurations almost limitless. Integrated programmable attenuators also add to the functionality and configurations can range from as few as three connections up to hundreds of RF I/Os.

JFW Industries
www.jfwindustries.com

Miniature PCB Slide Switches

C&K Components has developed a series of low-profile, cost-effective miniature slide switches. Designated the JS Slide Series, the switches are ideal for applications with limited PC board space and height restrictions, including mobile telecommunications, computers and remote control equipment. One- or two-pole JS Slide Series miniature switches feature only 2 mm (.079') high actuators (some models as low as 1 mm), making them very easy to operate. Available in single-, double- and triple-throw circuits, the JS switches are offered in surface mount and through-hole configurations. The switches are lead free and process compatible. The devices are available in tape and reel packaging.

C&K Components
www.ck-components.com

Capacitors & Inductors

Broadband Multilayer Capacitors

ATC's new 530L series multilayer broadband capacitor provides low insertion loss performance over multiple octaves of frequency spectrum. The 530L capacitor is compatible with high-speed automated pick and place SMT manufacturing. The 530L is ideal for broadband DC blocking, coupling, bypassing, and feedback applications in optical communications systems and equipment using high-speed digital logic.

American Technical Ceramics
www.atceramics.com

Magnetic Devices Added to Simulation Tool

ACME Magnetics USA and Intusoft announced a technological collaboration to incorporate ferrite cores produced by ACME Electronics Corporation into Intusoft's "Magnetics Designer" simulation product. Magnetics Designer automates the design of magnetic devices for manufacturing, plus builds a magnetic SPICE model for simulation of electronic systems. It runs on Windows 98 through VISTA and creates many types of layer and sector/split bobbin wound transformers and inductors. Its database contains thousands of cores, a wide variety of materials and wire, and both linear and saturable-core SPICE models.

ACME Magnetics USA
www.acmemagusa.com
Intusoft
www.intusoft.com

Expanded Product Series

AVX Corporation has enhanced and expanded its MIL-PRF-123 product offering. Available in molded radial, molded axial and two-pin dip leaded configurations, the expansion includes improved capacitance values, higher voltages and new tolerances. Capacitance values range from 0.1 pF in axial leads and up to 0.47 µF in radial leads and voltages range from 50 to 200V in radial and axial leaded configurations. AVX's MIL-PRF-123 Series enhancement includes the CKS05 and CKS06 molded radial products as well as the CKS11, CKS12, CKS14, CKS15 and CKS16 molded axial products. Pricing for the MIL-PRF-123 Series starts at $27.50 each for radial and $45.00 each for axial, in quantities of 100. Average lead time for both radial and axial is 28 weeks.

AVX Corporation
www.avx.com

2008 Product Catalog

Pulse, a Technitrol Company, announces the release of the 2008 Pulse Product Catalog. The catalog showcases Pulse's transformer line and an expanded portfolio of antennas for point of access, wireless devices, and automotive applications. The catalog contains product overviews, charts with pertinent electrical specifications, and data sheet references for the majority of catalog components.

Pulse, a Technitrol Company
www.pulseeng.com

"Instrumentation" is the First of our New Quarterly Supplements Highlighting Important Product Families for High Frequency Circuit and System Design

Multi-Band Mobile WiMAX Receiver

Agilent Technologies Inc. has introduced a measurement receiver for Mobile WiMAX, extending the technology support of its existing drive test receiver platform. The new Agilent W1314A platform has options to support GSM, UMTS, IS95, cdma2000, 1xEVDO, iDEN and WiMAX technologies. According to Jonathan Dunbar, general manager of Agilent's Drive Test business, "Unlike a standard Mobile WiMAX subscriber device, the network independent receiver measurements enable users to clearly see individual sector coverage areas and validate that they meet the design criteria.' Benefits of the Agilent W1314A-E01 receiver include:

- The ability to quickly troubleshoot handover and missing-neighbor issues, confirm coverage and pinpoint interference sources
- Support of up to eight frequency bands, which allows 2.3, 2.5 and 3.5 GHz Mobile WiMAX networks to be monitored by a single solution
- Small form factor and rugged casing which is easy to carry and able to withstand the rough environment of field-based testing
- Built-in high sensitivity GPS receiver that offers significantly enhanced position-reporting performance in dense urban environments and in many indoor situations

The Agilent W1314A receiver platform is available now with pricing varying with configuration.

Agilent Technologies
www.agilent.com/find/e6474a

QMA Test Cables for Microwave Applications

Times Microwave Systems has recently extended its successful line of SilverLine™ QMA Test Cables

to cover applications in the microwave market. The excellent frequency response of the new QMA-SMA, QMA-Type N and QMA-TNC adaptors make them suitable for use up to 18 GHz for most microwave applications. SilverLine test cables with QMA plug and QMA jack adaptor exhibit a low VSWR of 1.30:1 through 18 GHz. Also improved are the ruggedness and durability of the QMA interface, doubling the mating life. Features and benefits include: snap on, pull off adaptors; 18 GHz operation (SMA, Type N, TNC); 5,000 mate life cycle; 360° DUT rotation while mated with little or no performance change; and durable, all stainless steel construction. In addition to the cables, a full complement of 29 coaxial adaptors for 2-way, RF and microwave use are currently available in both plug and jack configurations.

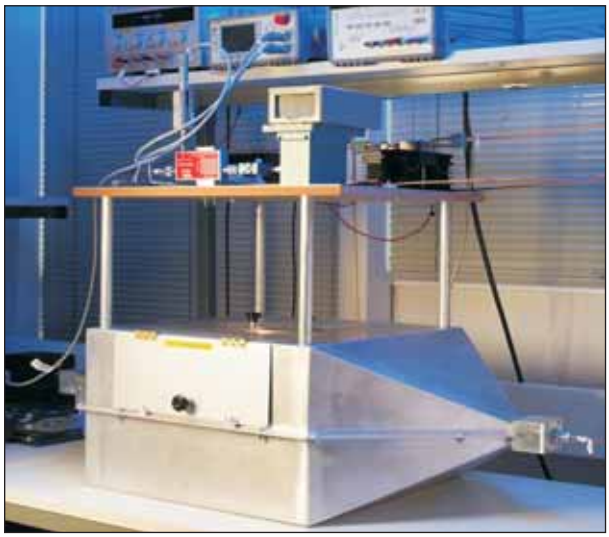
Times Microwave Systems
www.timesmicrowave.com

45 nm-Capable DC/RF Parametric Probe Card

Cascade Microtech has introduced two new Pyramid® parametric probe cards that allow single-pass high performance DC and RF measurements and reduce the cost of parametric production test for semiconductors with advanced processes nodes at 65 nm, 45 nm and beyond. These leading-edge probe cards leverage Cascade Microtech's new Pyramid Plus™ parametric probe card manufacturing technology. The exclusive Pyramid Plus membrane manufacturing process enables multiple specification improvements such as state-of-the-art leakage performance, to 1 fA with a 5-second settling time, improved parametric performance, and reliable contact on smaller test pads. Cascade Microtech's membrane technology is unique in its

ability to integrate 20 GHz transmission lines and guarded traces to the probe tip, respectively, reducing crosstalk and improving settling time, and wafer acceptance testing with existing needle technology. Cascade Microtech's probe card technology is unique in its ability to make these low-level DC measurements while at the same time facilitating RF measurements in a single solution. The parametric Pyramid Probe cards are available in either DC only (PDC50) or DC plus RF (PRF50) configurations, with options for pad size and leakage specifications. The probe cards are compatible with Keithley S600 Series and Agilent 4070/4080 Series parametric testers.

Cascade Microtech
www.cascademicrotech.com



TEM Cells for Calibration of Field Strength Meters, Monitors and Probes

The Engineering Division of Link Microtek has expanded its line-up of TEM cells with a range of models specifically designed for the testing or calibration of field strength meters, monitors or probes. Suitable for incorporating within an ATE system, the TEM cells feature an equipment support tray positioned at the correct height for measurement, a side access screened door to enable equipment to be placed inside the unit, and top and side ports to allow access for cables. The TEM cells can be specified with overall lengths from 600 to 2400 mm, and they are available with maximum frequencies from 100 MHz to 500 MHz. The dimensions of the main section and tapered ends are selected to provide a 50-ohm characteristic impedance along the whole length of the cell, thereby creating a uniform electromagnetic field of known pattern and intensity. Equipped with female N-type connectors as standard, the TEM cells are manufactured from aluminium, with an optional alochrome and epoxy paint finish.

Link Microtek, Engineering Division
www.linkmicrotekeng.com

Stressed Eye Measurement Suite for IEEE 802.3-2005 Compliance

Anritsu Company introduces a Stressed Eye Measurement Suite for its MP1800A series of Signal Quality Analyzers that offers industry leading repeatability for measuring the average output power level difference (OMA), extinction ratio, and Vertical Eye Closure Penalty (VECP) of optical signals. The hardware and software solution provides designers and manufacturers of 10GBASE-L/10GBASE-E optical modules and transmission equipment with an instrument that reduces measurement times and increases efficiency. Consisting of Stressed Eye Measurement Control Software, Stressed Eye Transmitter, and Optical Receiver, the suite supports stressed receiver conformance to ensure products are IEEE 802.3-2005 compliant. OMA, extinction ratio, and VECP measurements can be made with a power penalty of ±0.3 dB, ensuring precise measurements when the MP1800A's high-accuracy auto-calibration function is used. The transmitter supports output of both 1310- and 1550-nm wavelengths, and the control software supports power penalty tests, jitter tolerance margin measurements, and jitter sweeps for jitter tolerance GO/NO GO checks. The measurement suite is designed to work with an MP1800A analyzer configured with a built-in synthesizer, pulse pattern generator, and error detector. In addition, the analyzer outputs a high-stability, high-quality, optical signal for use as a reference light source. The MP1800A has a base price of $46,500. Delivery is 8 weeks ARO.

Anritsu Instruments Company
www.us.anritsu.com

Power measurements have never been so mobile

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Agilent U2000 Series USB Power Sensors

- *Frequency range from 9 kHz to 24 GHz*
- *Wide dynamic range from -60 dBm to +20 dBm*
- *Built-in triggering for synchronization with external instrument*
- *Internal zeroing capability*
- *Feature-packed Power Analysis Manager software*

This power sensor goes where you go. Whenever and wherever you need to make power measurements - whether for manufacturing, antenna or base station testing - the Agilent U2000 Series of USB power sensors is always up to the task.

With the U2000 Series, you can make measurements without a power meter. And you won't need power adapters and triggering modules so often necessary with other USB-based solutions. Now, even multiple-channel power measurements are easier and more affordable.

Simply plug the U2000's cable into your PC, or selected Agilent instruments, and start monitoring and analyzing with the N1918A Power Analysis Manager software. When you need high performance power measurements in a portable and convenient package... you'll want to use the Agilent U2000 Series power sensors.

Find out more at
www.agilent.com/find/USBPowerPromo

50% Off Power Analysis Manager*
Valid only until 30 June 2008

*Get 50% discount on N1918A Power Analysis Manager with purchase of any U2000 Series USB power sensors

Agilent Technologies

Get info at www.HFeLink.com

Test & Measurement Business News

TÜV Rheinland Holding AG and **TÜV SÜD AG** plan to merge. The two German companies are currently reviewing the details of their combination. An internationally powerful technical services group with the core competencies Testing, Inspection, Certification and Training shall be created through the merger of the supporting associations and subsequent consolidation of the two groups by the end of the year. The new company would employ about 25,000 people worldwide and achieve sales of more than EUR 2.2 billion. The project is subject to approval by the responsible antitrust authorities and the relevant committees of the associations and the groups. The merger timetable calls for due diligence and initiation of the reviews by the relevant antitrust authorities to be in place by May 2008. With regard to the employees of the companies, both companies' CEOs stated that the merger will not result in any job losses.

Anritsu Company has been awarded a contract in excess of $500,000 by the **National Football League** (NFL) to supply the league with 36 MS2721B Spectrum Master™ handheld spectrum analyzers. The MS2721B spectrum analyzers are being used by the NFL's Game Day Frequency Coordinators (GDC) to research, troubleshoot, and analyze the RF spectrum at the league's 32 stadiums before, during, and after games. RF communications is used by team coaches, all broadcast TV and radio entities, medical teams, team security and public safety. The MS2721B units delivered to the NFL are configured with interference analysis and channel scanner options to ensure that the GDCs efficiently coordinate the 400 or more frequencies used at each stadium during a regular season NFL game.

TREK, Inc. announces that four of the company's sales engineers were recently certified by the Electrostatic Discharge Association (ESDA) with the designation of "ESD Certified Professional–Program Manager." The four individuals at TREK receiving certification include John Clack, Chris Lemke, Elwin Rego and Ron Slaby. The certification program was designed by the ESDA for individuals who are involved in designing, implementing, managing and auditing electrostatic discharge (ESD) control programs. In addition to TREK staff, the program has certified individuals from IBM, NASA, Raytheon, Seagate, Trane and other institutions interested in electrostatic discharge. ESD management is essential in semiconductor, electronic assembly, hard disk drive and other electrostatic-sensitive environments and applications. Other applications that benefit from ESD measurement and management tools include medical/biomedical devices, powder handling, electrostatic painting/coating, test & measurement, instrumentation, quality control, materials evaluation, military, automotive, aerospace, and R&D applications.

Comsys Communications and Signal Processing and **Agilent Technologies Inc.** have announced a collaboration under which the Agilent N8300A Wireless Networking test set will be used to help roll out Mobile WiMAX™ compliant chip sets. The two companies will work together on the speed-optimization of RF power-calibration and production-test systems for Mobile WiMAX modules. With Agilent's support of Comsys chipsets, modules based on Comsys ICs can be calibrated and tested with the greatest speed and efficiency.

The Agilent N8300A is a wireless networking test set and OFDMA measurement application software, forming a complete one-box transmitter and receiver test solution for Mobile WiMAX devices. This solution effectively meets the needs of cell phone, ODM and CM manufacturing engineers testing WiMAX mobile subscriber devices or modules that use IEEE 802.16e-2005.

Comsys is a supplier of multimode baseband chipsets for the IEEE 802.16e-2005 standard, on which WiMAX Forum's mobile profiles are based, as well as for the fixed WiMAX IEEE 802.16-2004 standard. Comsys has recently launched two reference design platforms, enabling companies to develop converged cellular and mobile WiMAX terminals.

Keithley Instruments has recently updated and expanded its online catalog at www.keithley.com. New products featured include: Model 2100 6-1/2-Digit USB DMM, Series 3700 System Switch/Multimeter and plug-in card family, new low current (1 fA) capability for the Series 2600 SourceMeter® line of I-V test solutions, Model 4200-CVU integrated C-V option and Model 4200-PIV-Q package for the Model 4200-SCS Semiconductor Characterization System, Model 2920 RF Vector Signal Generator, Model 2820 RF Vector Signal Analyzer, and the company's new 4×4 MIMO RF test system.

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you can afford it

for synthesizers from PTS, you don't even have to ask,

all our technical information, (web, catalog, data sheets) shows the price of our units. PTS produces fast switching, low noise synthesizers with the best performance/price ratio on the market. Our total installed base, first in the ATE industry, confirms this fact.

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PROGRAMMED TEST SOURCES, INC.

Get info at www.HFeLink.com

Passive Intermodulation Test System

Boonton, a Wireless Telecom Group Company, introduces its new PIM 20 ultra portable test system for Passive Intermodulation. The portable PIM 20 is a rugged, reliable tool for RF field technicians, battery driven and self calibrating. When connected to the component or system, users can read the measurement value (dBc) directly from the display. PIM 20 generates two RF signals that can be set between 20 dBm and 33 dBm, thus allowing to measure components close to their predetermined power range without overloading them. The frequencies of the RF tones can be customized. PIM 20 offers a sensitivity range from –80 dBc to up to –155 dBc (at 850 MHz). The PIM 20 enclosure provides IP55 protection (lid closed) and has dimensions of 343 × 327 × 152 mm. Included accessories are a 9-240 VAC power supply, 4m type N test cable, 7/16 to N adapter, 12 VDC car adapter, accessories pouch, user manual and a quick start guide.

Boonton, A Wireless Telecom Group Company
www.boonton.com

Updated Characterization Software

Keithley Instruments, Inc. announces the availability of ACS (Automated Characterization Suite) V3.2 software for semiconductor test and characterization at the device, wafer, and cassette level. Version 3.2 further enhances the capabilities of ACS integrated test systems by adding more powerful multi-site parallel test capabilities, results binning for die sort applications, new wafer level plotting capabilities, and support for Keithley's new Models 2635 and 2636 System SourceMeter® instruments with 1 fA current measurement resolution. Pricing for the ACS integrated test systems is based on the particular configuration and customization options. Availability is immediate.

Keithley Instruments Inc.
www.keithley.com/pr/070

New Satellite Simulators

Tampa Microwave announced the availability of three additional models to their satellite simulator product family. The new Satsim products eliminate the need for live satellite time, saving time and expense for system users and product developers. Quad Band SatSim model LTT-03-W-198-ANT incorporates all of the features of the standard products, such as simultaneous band operation (C, X, Ku and Ka band), adjustable attenuation, and wired remote control for band selection. It also allows the embedded internal antennas to be bypassed for use of external customer-provided antennas. The MSS-2300-BEA-S is a single Ku-band simulator with selectable beacons that covers an input frequency of 14.0-14.5 and output frequency of 11.7-12.2 GHz. The third new offering, MSS-9800-BEA-S is a single Ka-band Satsim with selectable beacons that covers the commercial Ka band input frequency of 29.5-30 GHz and output frequency of 19.7-12.2 GHz.

Tampa Microwave
www.tampamicrowave.com

New Test & Measurement Catalog

TEGAM, Inc. offers its newly updated 2008 Product

Catalog, featuring the company's waveform generators, precision amplifiers, RF power calibration and low level measurements. The new format will allow TEGAM to update the catalog more frequently, giving customers the most up-to-date information. Product datasheets containing complete specifications are available on the company's website.

TEGAM, Inc.
www.tegam.com

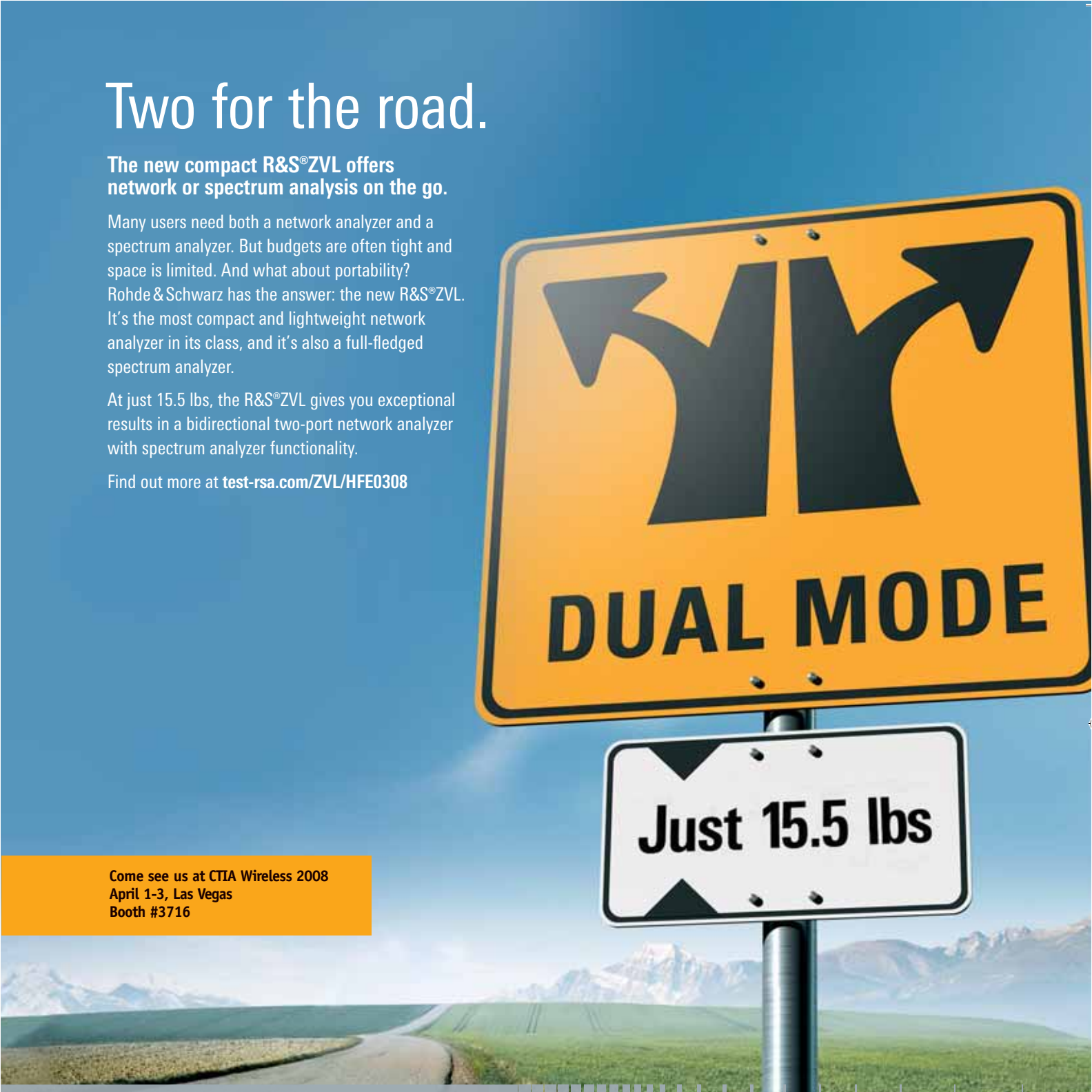
Two for the road.

The new compact R&S®ZVL offers network or spectrum analysis on the go.

Many users need both a network analyzer and a spectrum analyzer. But budgets are often tight and space is limited. And what about portability? Rohde & Schwarz has the answer: the new R&S®ZVL. It's the most compact and lightweight network analyzer in its class, and it's also a full-fledged spectrum analyzer.

At just 15.5 lbs, the R&S®ZVL gives you exceptional results in a bidirectional two-port network analyzer with spectrum analyzer functionality.

Find out more at **test-rsa.com/ZVL/HFE0308**



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Satellite Link Emulator

dBm Corp. today announced that it has increased the precision of its Model SLE700 satellite link emulator to accommodate the needs of next-generation communication satellites. When testing Earth terminals and satellite payloads during development, satellite payload developers must evaluate how the communications hardware will perform during service. Characteristics such as propagation delay, fading, Doppler shift, and phase shift must be induced at precise levels and times to accurately mimic the conditions that occur as a satellite changes its position in the sky. The Model SLE700 provides the transmission path and signal impairments required for these measurements and is typically embedded in a large automated test system that performs hundreds of such tests. The SLE700 has increased the maximum RF bandwidth to 45 MHz to accommodate wideband modulation schemes, increased signal-to-noise ratio by 15 dB and increased rejection of spurious signals by 10 dB.

dBm Corp.
www.dbmcorp.com

Signal Generators Support 1xEV-DO Rev. A

Rohde & Schwarz introduces an option for its high-performance RF and baseband signal generators that allows the instruments to generate signals in conformance with Rel. 0 and Rev. A of the CDMA 1xEV-DO standard. The new capability is available as Option R&S-SMx-K47 for the R&S-SMU200A, R&S-SMJ100A, and R&S-SMATE200A vector signal generators, as well as the R&S-AMU200A baseband signal generator/fading simulator and as R&S-AFQ-K247 for the R&S-AFQ100A IQ modulation generator. Current owners of these instruments can add the option as well. 1xEV-DO Rev. A is an enhancement for improved data throughput rates in the CDMA2000 family and offers greater performance than its predecessor, 1xEV-DO Rel. 0. It provides faster packet establishment on both the forward and reverse links, as well as modifications that reduce latency and improve data throughput. It also increases the maximum burst downlink rate from 2.45 Mb/s in 1xEV-DO Rel. 0 to 3.1 Mb/s, and increases the maximum uplink data rate from 153 kb/s to 1.8 Mb/s.

Rohde & Schwarz
www.rohde-schwarz.com

New Test Cable Brochure

A new Rosenberger tri-fold brochure features updates on the company's popular RFlex® cable assemblies (standard connector configurations with ruggedized molded strain reliefs) and SMA+® cable assemblies (SMA connectors modified to operate to 36 GHz). Also included are new product line additions including SMA Quick-Lock™, SMA Push-On™, and RTK-028 cable assemblies. The SMA Quick-Lock™ provides a unique locking mechanism to replace threaded SMA male connections. The SMA Push-On™ offers a faster slide on connection. RTK-028 is Rosenberger's new triple shielded cable, comparable to RG 316 DS but extremely flexible. In addition, the brochure provides an overview on the company's unique value proposition in supporting customer requirements for semi rigid cable assemblies.

Rosenberger
www.rosenbergerna.com

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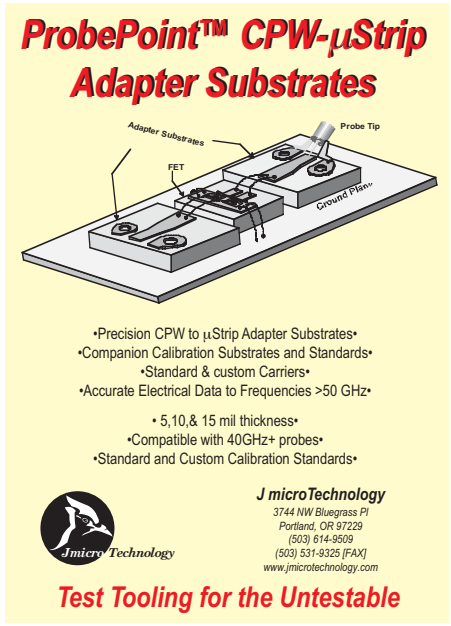
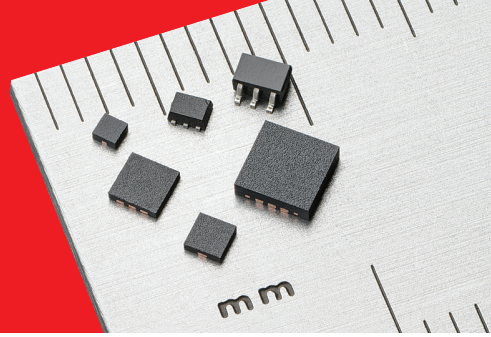


Get Info at www.HFeLink.com

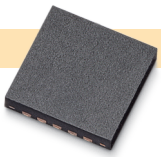
NEC RFIC Switches

Looking for a switch that's tailored to meet the specific needs of your design? *Think NEC.*



NEC's commitment to GaAs and CMOS RFIC Switch technologies means you get innovative new devices with industry-leading performance, in industry-standard *and* miniaturized packages. Our broad selection includes SPST, SPDT and multi-throw switches, internally terminated devices, 1.8 V-controlled switches, and single control voltage models. For a complete list with specifications, visit **www.cel.com**.

	STANDARD SPDT	DESCRIPTION	Mobile Comm	Short Range Wireless	WLAN / WiFi	Bluetooth/ZigBee	WiMAX
	UPG2009TB	High power, high isolation, low insertion loss	●	●	●		
	UPG2155TB	High power, low harmonics, for GSM	●	●			
NEW	UPG2157T5F	High power, non-reflective, optimized for WiMAX			●		●
	UPG2158T5K	Medium power, miniature pkg, spec'd at 1.8 & 2.7 V	●	●	●	●	
NEW	UPG2159T5K	Low insertion loss, high isolation, miniature package	●	●		●	
	UPG2163T5N	2 – 6 GHz, industry's best insertion loss, compact pkg		●	●		
NEW	UPG2176T5N	High power, non-reflective, compact package			●		●
	UPG2179TB	Medium power, high performance, standard pin-out	●	●	●	●	
NEW	UPG2185T5K	2 – 6 GHz, miniature 1.0 x 1.0 x 0.37 mm package	●		●		
	UPG2214TB/TK	Low cost, performance guaranteed at 1.8 and 3 Volts	●	●		●	
	SINGLE CONTROL SPDT						
	UPG2010TB	High power, high isolation, low insertion loss	●	●	●		
	UPG2012TB/TK	Great at 2.4 GHz, industry-standard or miniature package	●	●		●	
	UPG2015TB	Medium power, great performance	●	●	●	●	
	UPG2160T5K	Miniature 1.0 x 1.0 x 0.37 mm package	●	●			
	UPD5713TK	Low cost CMOS, miniature package	●	●			
	MULTI-THROW SWITCHES						
	UPG2031TQ	**SP3T** Ideal for CDMA2000-1x dual band, GPS	●	●	●	●	
	UPG2150T5L	**SP3T** Extra isolation for WiFi & Bluetooth apps	●		●	●	
	UPG2162T5N	**DPDT** 2.4 – 6 GHz dual-band, compact, high isolation	●	●	●		
	UPG2164T5N	**DPDT** 2.4 – 6 GHz dual-band, compact, low insertion loss	●	●	●		
NEW	UPG2181T5R	**DP4T** High power, non-reflective					●
NEW	UPD5731T6M	**SP4T** CMOS, only two control lines req'd, miniature pkg	●	●			



Custom Antenna Switches, too!

Let us put NEC technology to work for you in a *Custom Antenna Switch* designed to meet the needs of your specific application. Please inquire.

NEC

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Applying System-in-Package Technology to 16-bit Digital Receiver Design

By Todd Nelson
Linear Technology Corp.

This article describes a new SiP module that simplifies digital receiver design by combining the driver and anti-aliasing filter circuitry with a high-performance analog-to-digital converter

The relentless need to compress design cycle time requires first-time success for circuit design and board layout, yet extracting all of the performance from high-speed, high-resolution data converters often requires skills and experience that only a few possess. This is especially true in high-speed receivers as part of down-conversion chains in high-speed instrumentation or high-sensitivity wireless base stations, where the latest generation of analog-to-digital converters (ADCs) now have sample rates over 100 MHz and resolution up to 16-bits. Applying System-in-Package (SiP) technology bridges the experience gap and helps keep pace with increasing performance and time-to-market demands.

SiP technology is commonly used in consumer applications and has been successfully applied to DC/DC converters to help designers overcome design challenges for a wide range of applications. Linear Technology is now applying this technology to high-speed 16-bit receivers. Years of applications expertise have been packaged with their industry-leading high-speed ADCs and latest amplifiers to achieve the highest performance solution in a space-saving form factor. The LTM9001 µModule™ Receiver Subsystem integrates a 16-bit, 130 Msps ADC with a fixed gain amplifier, anti-aliasing filter and bypass capacitance, as shown in Figure 1 (on next page).

Dissecting the Module

The µModule receiver consists of wire-bonded die, packaged components and passives

mounted on a high performance, four-layer substrate. Several different versions of the LTM9001 will be available. The LTM9001-AA, as the first release, is configured with a 16-bit, 130 Msps ADC. The amplifier gain is 20 dB with an input impedance of 200 ohms and an input range of ±250 mV. The matching network is designed to optimize the interface between the amplifier outputs and the ADC inputs under these conditions. Also, there is a second order bandpass filter designed for 162.5 MHz, ±25 MHz to prevent aliasing and to limit the noise from the amplifier.

Subsystem Analysis

RF signal chain analysis uses the 50-ohm single-ended signal path as the most basic assumption. The math works out best with 50 ohms or multiples thereof. Differential signal paths are commonly 200 ohms and are easy for the RF engineer to accommodate. A traditional ADC input is not an easily-matched multiple of 50 ohms and is in fact a complex, switched-capacitor structure that kicks back current pulses at the sample rate and is thus challenging to use in quick RF calculations.

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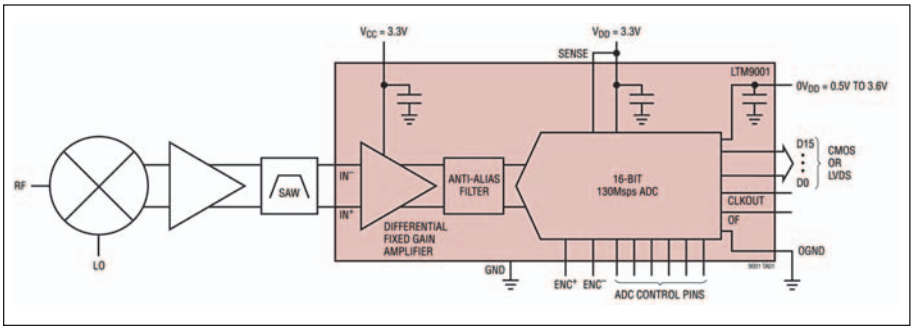

Figure 1 · This simplified IF receiver diagram demonstrates how the LTM9001 eliminates the need to design and implement the critical driving circuitry for the ADC.

know the input power capability of the ADC in dBm, but this is never given on ADC data sheets. The next best thing is to know the input voltage range and the input impedance to calculate power. The input range is specified for a traditional ADC, but the impedance, as mentioned, is not a fixed, resistive number. The LTM9001-AA, however, with its ±250 mV input span and 200-ohm differential input impedance, allows the input power to be easily calculated as –14 dBm.

The low noise, low distortion amplifier stage provides gain without adding significant noise or distortion to the signal. Despite the low noise of the amplifier, noise is multiplied by the gain of the amplifier, so higher gain unavoidably adds noise to the system. However, the input range of the amplifier is proportionately smaller due to the gain, and this smaller input range allows for lower distortion from the preceding components.

In RF terms, noise figure (NF) is commonly used. Noise figure is the ratio of the output noise power of a device to the portion attributable to thermal noise in the input termination, usually specified at room temperature. In ADC data sheets, noise is specified by its signal to noise ratio (SNR) or similar measurements. SNR is the ratio between the RMS amplitude of the fundamental input frequency and the RMS amplitude of all other frequency components, except the first five harmonics. Amplifiers may specify both, but neither term is universally applicable since they infer certain conditions such as the 50-ohm impedance implied in the NF measurement or the Nyquist bandwidth implied for SNR. Amplifiers may also specify noise in nanovolts-per-root-hertz (nV/√Hz), which allows you to do the translation. The LTM9001 specifies 72 dB SNR with the 200-ohm input impedance and a bandwidth-limiting filter. By using the SiP technology, this eliminates the steps required to convert NF to nV/√Hz, convert SNR to nV/√Hz, take the root-sum-square of the values in the allotted bandwidth and then convert the result back to SNR.

Differential Filter Design

The anti-alias filter between the ADC driver and the ADC inputs limits the wideband amplifier noise and helps preserve the high SNR of the ADC. State-of-the-art ADCs and drivers are differential, and designing filters for differential signals is more complicated than traditional single-ended designs. While the design can be implemented using two single-ended filters, the result is somewhat less robust than a true differential filter. The most obvious difference is that differential designs use a parallel component between the two signal paths instead of a component to ground for each single-ended path. With a ground reference, mismatch of two single-ended filters may introduce imbalance, resulting in differences in phase or amplitude. These differences exacerbate the imperfection of the ADC sample-and-hold circuitry, causing an increase in second harmonic distortion.

The anti-alias filter integrated in the LTM9001 is a simple two-pole L-C type differential design. It is entirely contained within the LTM9001 so no design is required. The design is characterized and 100% tested, with SNR and distortion fully specified over temperature. In the case of the LTM9001-AA, the filter is a 50 MHz bandpass centered at 162.5 MHz. Other versions of LTM9001 with different filter frequencies and bandwidths are in development.

Circuit Layout

Extracting the full performance from 16-bit, high-speed ADCs requires careful layout in addition to good circuit design. Printed circuit board (PCB) layout has a significant impact on the performance even if the circuit topology and component values are correct. The RF layout designers have lists of "good practices" depending on the operating frequency of the circuit. Such lists include recommendations such as avoiding sharp corners and keeping the signal paths symmetric and isolated from the clock inputs and digital outputs. A common mistake is to assume that an IF of 140 MHz means that optimum high frequency layout techniques are not required. But for high-performance ADCs like the one in the LTM9001, the bandwidth of the sample-and-hold is over 700 MHz. High frequency noise can be picked up by the sample-and-hold, reducing the SNR. This is an area that requires extensive experience.

Another simple example is the placement of supply bypass capacitors. A common problem with traditional ADC board layouts is excessive noise due to long traces from the bypass capacitors to the ADC. Good

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Vibration:	MIL-STD-202, Method 204 Condition D (20 Gs)
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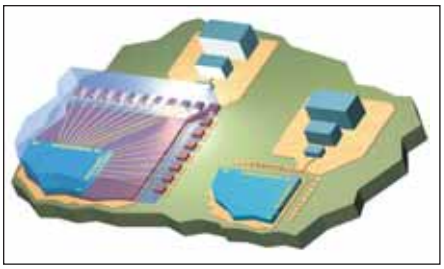

Figure 2 · Comparison of bond wire lengths in standard packages and SiP.

practice is to locate the capacitor as close as possible to the supply pin of the device. In discrete designs, the die is wire-bonded to the leadframe of the IC package. The bypass capacitor is then slightly further away, even in the best circumstance. The package size is determined by the number of pins on its periphery as well as the area required to adequately dissipate the power of the device. Therefore, the bond wires are considerably longer than those in the µModule receiver, 3.5 mm (left image) as compared to 0.8 mm (right image) in Figure 2. As a result, the internal bypass capacitors in the LTM9001 are much closer to the die than is possible in a discrete design. Thus, the LTM9001 has a much smaller "AC footprint," reducing the risk of collecting noise from unintended sources and raising the noise floor.

Both the supply side and the grounded side of the capacitor should be close to the device. Relative to the supply pin, should the capacitor return to the upstream or downstream side of the amplifier? Where should the ADC bypass capacitors return? It depends on the design and layout of the IC, which is not described in the data sheet. In many cases it does not matter, but in some cases a particular supply pin delivers power to the input stage or output stage of the amplifier, so returning to the upstream side or the downstream side is significant. In this regard, the designers of the LTM9001 have the unique advantage of working with

Figure 3 · A photo of the LTM9001 evaluation board.

the designers of the individual amplifier and ADC components to achieve the best placement possible.

A discrete, differential bandpass filter will have series inductors in each side of the signal path. Good layout practice suggests that both inductors will be side by side for best symmetry. A general rule is that they should be one body-width apart—close enough to eliminate the far field effect, but not so close as to couple and reduce their effective inductance. There are many such rules, and most RF layout designers know them. But this portion of the design is often on the digital board and may be done by someone not engaged with RF layout on a consistent basis.

The LTM9001 substrate design incorporates these considerations, which are learned through years of applications experience. Furthermore, the entire collection of careful layout, proper circuit design and high-performance components is fully characterized and tested as a unit. While it is possible to purchase a matched set of components, the LTM9001 extends that concept to purchasing the layout, assembly and packaging of a matched set of over 30 components. The result is an important portion of a digital receiver system that requires very few external components (see Figure 3). The LTM9001 not only saves considerable time in design and layout, but potentially reduces the number of costly board revisions.

Conclusion

The relentless trend of compressing the design cycle time with higher levels of performance and higher frequencies is often in conflict with the need for experience working with these components and the time required to gain that experience. Even with a perfect circuit design, minor layout issues like placement of supply bypass capacitors can impact performance. SiP technology, now being applied to high-sensitivity, high-speed receivers, not only integrates IC components of differing process technologies with passive components, it also effectively integrates much of the layout skill required to maximize performance. By bridging the experience gap, these µModule receivers improve first-time success and accelerate the design cycle.

Product Notes

The LTM9001 line offers semi-customization (minimum order required)—the device can be configured for various sampling rates, and the differential ADC driver can be substituted with fixed gain versions ranging from 8 dB up to 26 dB. The anti-aliasing filters can also be configured as lowpass or bandpass filters, accepting input frequencies up to 300 MHz. The LTM9001 is packaged in a 11.25 × 11.25 mm LGA package, utilizing a multi-layer substrate, and occupies approximately half the space of the discrete implementation. The LTM9001 is available in production volumes, priced at $82.00 each in 1,000 piece quantities.

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Design and Development of Microwave Filters on Metallized ABS Plastic

By Jagdish Shivhare
Institute of Technology and Management

This article is a report on experiments investigating the design and construction of microwave filters using metallized plastic substrates and enclosures

This paper describes experiments to evaluate the use of metallized ABS plastic in place of metal and other substrates for cavity and planar structure communication filters, which can reduce the weight and cost. The specific gravity of ABS plastic is 1.05 gm/cm^3 compared to 2.7, 8.5 and 8.9 gm/cm^3 for commercial aluminum, brass and copper respectively. The cost of metallized ABS plastic substrate may be substantially less than the cost of traditional microwave laminates such as Rogers RT-Duroid. Some cavity bandpass filters have been developed and tested at center frequencies of 53.5 ±1.5 MHz, 86.5 ±4 MHz, 324 ±4 MHz, 600 ±9 MHz, 1200 ±150 MHz, 1537.5 ±7.5 MHz, 1636 ±10 MHz, 4190 ±20 MHz, 4590 ±20 MHz and 5.850-5930 GHz. Two-hairpin line filters at 1537.5 ±10 MHz and 1575.5 ±10 MHz, also have been developed and tested [1].

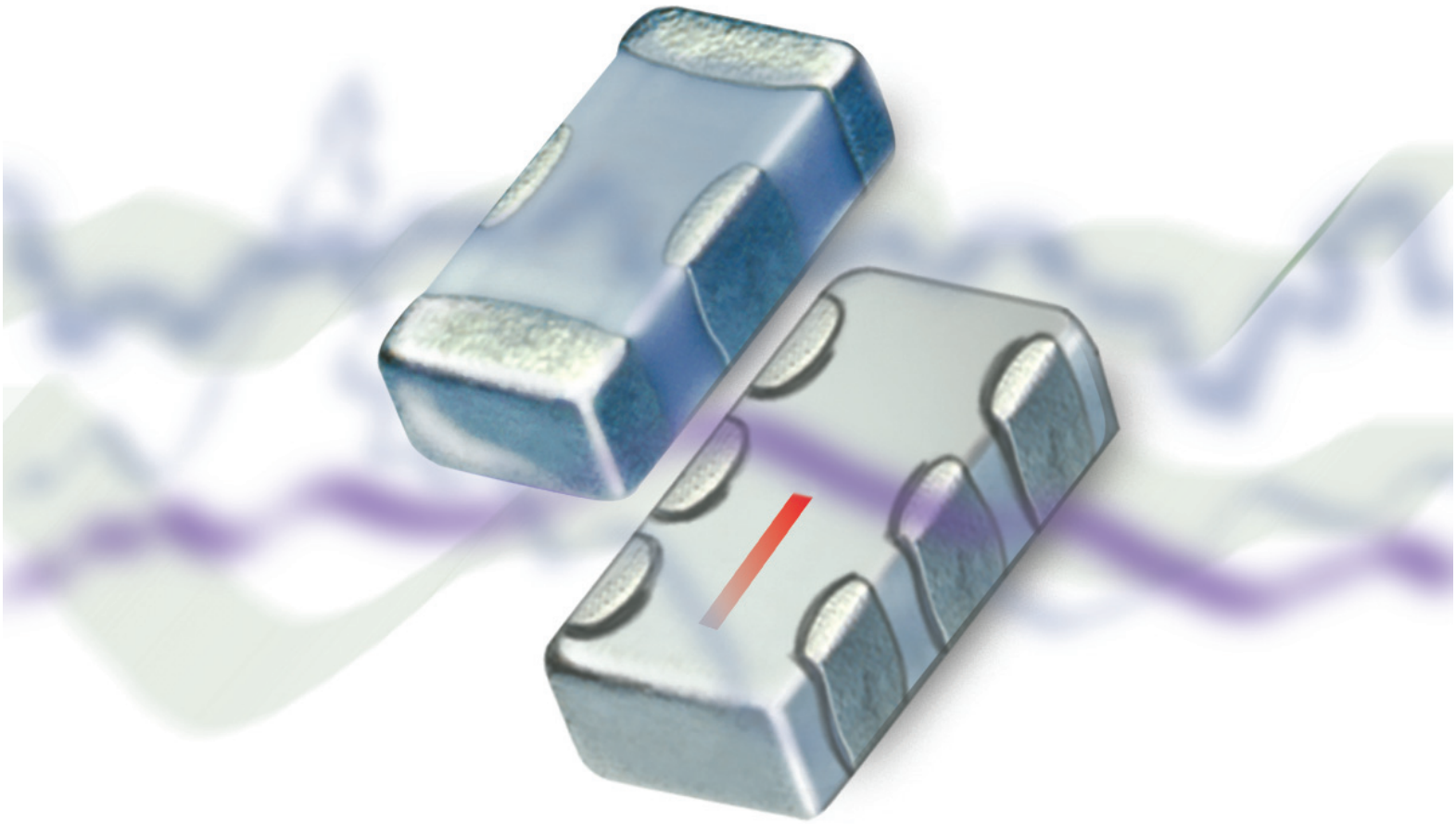
Introduction

Although there have been other efforts to use metallized plastic, metal remains the material universally used to make cavity filters, while PTFE laminates dominate microstrip and stripline filter designs. Therefore, their manufacturing cost is high. The electrical characteristics of ABS plastic show minor changes at normal operating temperature, humidity and frequency, and the dielectric properties are sufficiently good. ABS plastic exhibits a flat module curve over a wide temperature range. Dimensional tolerance can be maintained within 0.003 mm. Machining characteristics are similar to those of non-ferrous metals. The plastic may be drilled, punched, die-cut, routed, sawn and turned. Favorable electrical, mechanical, physical and environmental properties may increase its applicability as an alternative to metal to fabricate precise filters such as helical, combline, interdigital and coaxial cavity band pass filters in different frequency ranges. The ABS plastic may be used in place of PTFE substrate for planar structures [2].

The performance of two hairpin line (microstrip) band pass filters at 1537.5 MHz and 1575.5 MHz have been verified with the help of standard filters. The achieved insertion loss is high due to the higher dissipation factor of ABS. The insertion loss can be reduced to approach the loss of soft PTFE substrate (RT-Duroid # 5870, 1.58 mm thick with dielectric constant of 2.32) by doubling the thickness of ABS plastic sheet. However the 3 dB bandwidth is also doubled. So, if this compromise between insertion loss and bandwidth is an acceptable criterion, very low cost hair pin line filters may be developed by using the ABS plastic in place of a PTFE substrate [3].

Design Procedure

The existing design theory for any type of cavity band pass filter is applicable. No correction in design is required while using ABS plastic in place of metal. However, a few graphs have to be generated to use the ABS plastic as a substrate for hairpin line structure. Here, the design theory available for RT-Duroid #5870, of dielectric constant 2.32 and thickness 1.58 mm has been used to calculate the dimensions of a hair pin line band pass filter [4].



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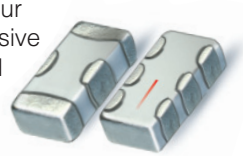

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Established design procedures and tables for any type of cavity, helical, combline, inter digital, coaxial cavity filters may be utilized. Similarly, design procedures available for planar structures such as parallel coupled, hairpin line band pass filters may be used [1, 2, 3]. Figures 1 and 2 show the results for the microstrip hairpin filters noted above. Additional results for other types of filters are shown in Figures 3 through 6.

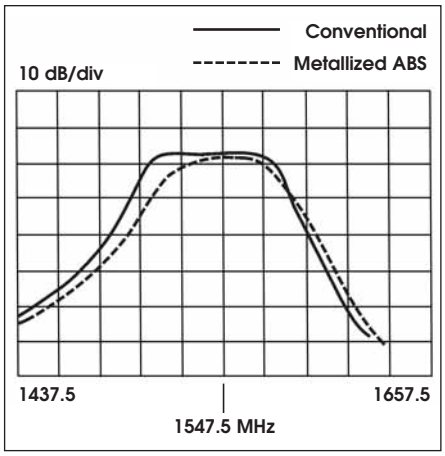

Figure 1 · Measurement of the 1537.5 MHz hairpin filter.

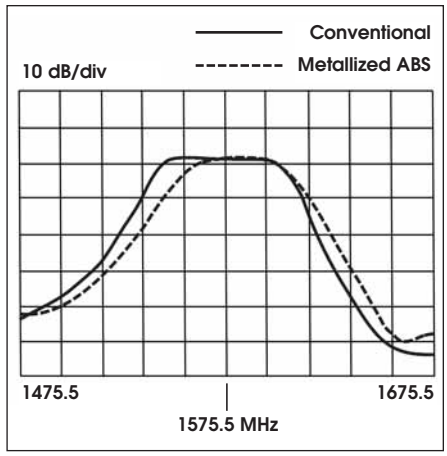

Figure 2 · Measurement of the 1575.42 MHz hairpin filter.

Important Properties of ABS

The electrical characteristics of ABS plastic show minor changes with temperature, humidity and frequency. The dielectric properties are sufficiently good to be considered for a number of electrical applications. ABS exhibits a flat modulus curve that varies only slightly over a wide temperature range. It exhibits high impact strength values. Good impact figures are maintained even at temperatures as low as –40° C. Unlike other thermoplastics, it is not significantly affected by variation in strain rate.

ABS plastic is resistant to weak acids and inorganic bases, although concentrated nitric and sulphuric acid produce disintegration. It is also swelled, softened or dissolved by most of the low order aromatics, ketones, esters etc. ABS plastic can be metallized, therefore an enclosure made of metallized ABS plastic

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$(\epsilon\ \text{eff})^{1/2} = \frac{\text{Difference of electrical length i.e. (EL150-EL50)}}{\text{Difference of physical length i.e. (150-50)}}$

Frequency of measurement in MHz	RT.DUROID #5880		ϵ eff	ϵ eff	ABS-PLASTIC # AP78 EP		ϵ eff	ϵ eff
	Measured Electrical length in (mm) for				Measured Electrical length in (mm) for			
	150mm physical length of 50 Ohm line	50mm physical length of 50 Ohm line			150mm physical length of 50 Ohm line	50mm physical length of 50 Ohm line		
45.0	230.76	96.26	1.345	1.81	231.22	93.82	1.374	1.89
650.0	232.18	96.18	1.360	1.85	233.15	95.35	1.378	1.90
1500.0	234.49	97.79	1.367	1.87	234.61	95.71	1.389	1.93
2500.0	235.82	97.62	1.382	1.91	235.70	95.40	1.403	1.97
4500.0	236.75	97.15	1.396	1.95	237.14	96.14	1.410	1.99
7000.0	242.11	97.91	1.442	2.08	250.32	108.22	1.421	2.0
10000.0	251.43	106.53	1.449	2.10	263.07	117.47	1.456	2.1
From DATA sheet of ROGERS CORP,USA. Er=2.22 ± 0.02, up to 10GHz. ϵ eff=1.89 for 50 ohm line. Dissipation factor: 0.0009. Measured ϵ eff is approximately equal to actual ϵ eff (1.89). Which verifies correctness or our test method of measurement. (Table-2)					From DATA sheet by ABSTRON Er=(2.8 – 3.3) at 1MHz. ϵ eff (measure) =1.89-2.12 for 50 ohm line from 45MHz to 10GHz. Dissipation factor: 0.0024 at 9.0GHz. Measured by wave guide method with 19x19x3 mm^3 sheet of ABS plastic.			

Table 1 · Network analyzer measurement of ε_{eff} of ABS plastic.

VERIFICATION OF CORRECTNESS OF OUR TEST METHOD

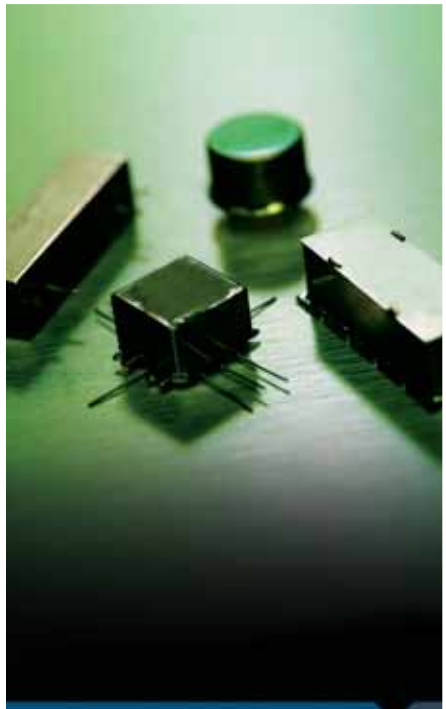
S.No.	For RT-DUROID # 5880 T ROGERS CORP. USA	For ABS-PLASTIC # AP78EP ABSTRON INDIA
01.	Thickness of substrate: 1-6mm	Chosen thickness for filters: 1-6mm
02.	As per DATA sheet: ϵ eff=1.89 for 50 ohm line upto 10GHz	Measured ϵ eff=1.89 to 2.12 from 45MHz – 10GHz
03.	Length of resonator $(\frac{\lambda}{4})$ at 1537.5 MHz & 1575.42MHz $\frac{\lambda}{4}=\frac{3\times10^{11}}{4\times1537.5\times10^{6}\sqrt{1.89}}$ =35.628 at 1537.5MHz $\frac{\lambda}{4}$ =34.483 at 1575.42MHz	Practically (found) lengths of hairpin line resonators are 31.0mm and 32.0mm at center frequencies 1537.5 & 1575.42 respectively. Therefore, $\sqrt{\epsilon_{eff}}=\frac{3\times10^{11}}{4\times1537.5\times10^{6}\times(\frac{\lambda}{4})}$ = 1.96 at 1537.5 MHz and 1.94 at 1575.42MHz.
04.	By our test method, ϵ eff =1.87 at 1500MHz and varies form 1.89 to 2.12 for 45MHz to 10GHz. Thus the measured values of ϵ eff are very close to the actual ϵ eff (1.89 for 50 ohm line), which verifies the correctness of our test method.	By the same test method, ϵ eff =1.93 (Table-1) for which is very close to the values found practically, ϵ eff=1.94 & 1.96 at 1537.5MHz & 1575.42MHz. This also provides the proof of the correctness of our method adopted for measurements of ϵ eff.

Table 2 · Summary of test methodology.

behaves electrically in a similar manner as the metallic enclosure.

ABS with 10% Butadine is more suitable for electroplating than ABS with 16 to 27% Butadine. Several trials were conducted for electroplating on ABS plastic. The articles are immersed in a mixture of chromic and sulphuric acid to improve mechanical adhesion. Poor etching leads to skip plating or poor adhesion of the plate and possible blistering. Thus, etched articles are to be treated with sensitizer and activators, Stannous chloride and palladium chloride solutions are used for this purpose. The deposited palladium nuclei on the plastic surface initiates electroless plating of copper, nickel, gold or other metals.

We carried out electroless copper deposition for our work. The purpose of plating on ABS is to get highly conductive coating. For this, it is finally deposited with electroplated copper and silver.



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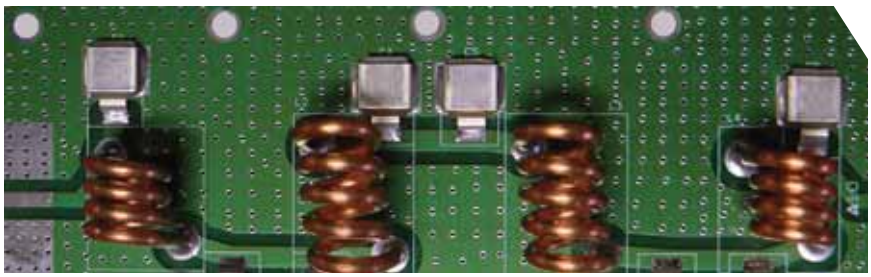
Type of filter	Freq. Band MHz	Center Freq. MHz	Band width MHz	Insertion loss dB	I/O return loss dB	Stop band attenuation dBc	Size (LxBxH) MMxMMx MM	Weight grams
VHF/UHF								
Helical	52-55	53.5	± 1.5	1.0	16	30dBc @60MHz	200x50x72	80
Helical	85-88	86.5	± 1.5	1.0	16	30dBc @80MHz	200x50x72	80
Helical	320-328	324.0	± 4.0	6.0	15	>30dBc @ ± 8MHz	105x38x25	41
Helical	591-609	600.0	± 9.0	2.2	20	>30dBc @ ± 18MHz	100x23x33	28
Combline	1050-1350	1200.0	± 150	1.5	15	>30dBc @ ± 300MHz	155x45x30	55
L-BAND								
Co-axial	1530-1545	1537.5	± 7.5	0.4	20	>30dBc @ ± 90MHz	130x44x37	90
Co-axial	1626-1646	1636.0	± 10	0.4	20	>30dBc @ ± 90MHz	152x52x41	130
S-BAND								
Combline	2500-2690	2595.0	± 85	1.5	16	>30dBc @ ± 2000MHz	120x25x20	110
C-BAND								
Combline	4170-4200	4190.0	± 20	1.5	15	>30dBc @ ± 40MHz	107x21x18	30
Combline	4570-4610	4590.0	± 20	1.5	15	>30dBc @ ± 40MHz	126x23x17	40
Combline	5850-5930	5890.0	± 40	2.0	16	>30dBc @ ± 80MHz	95x18x12	50
Ext. C-BAND								
Combline	6725-7025	6835.0	± 150	2.0	15	>30dBc @ ± 500MHz	100x11x13	100

Table 3 · Design and fabrication details of the microwave bandpass filters.



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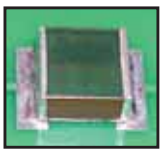

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Conclusion

A number of cavity and microstrip band pass filters have been tried up to 6 GHz. The performance of the cavity as well as the microstrip filters also were tested over the temperature range of –20°C to + 60° C, with a minor shift in the center frequency without affecting bandwidth and stopband attenuation. It has been noticed that the shift in the frequency depends upon the size and structures of the filters. In particular, at the higher frequencies, the size of the fingers in combline filter is very small, which increases the shift in center frequency. But, it is less than the commercial aluminum body filter. In general, electronic performance is fully satisfactory, but mechanical performance requires further improvement.

Editor's note—Original plots were not available to the author. The re-drawn figures are not precise, but show the general shape of the filter responses.

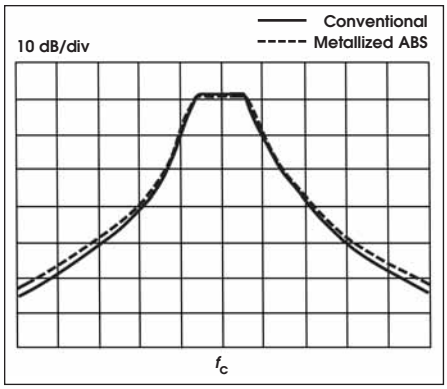

Figure 3 · Bandpass plots for the 1537.5 MHz coaxial cavity filter.

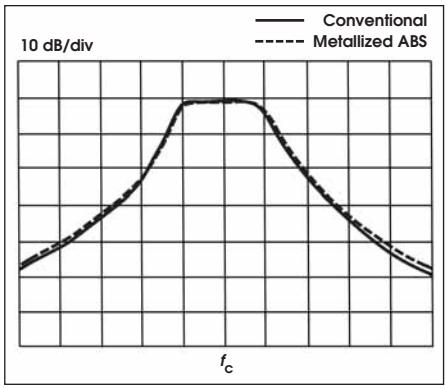

Figure 4 · Bandpass plots for the 1636.0 MHz coaxial cavity filter.

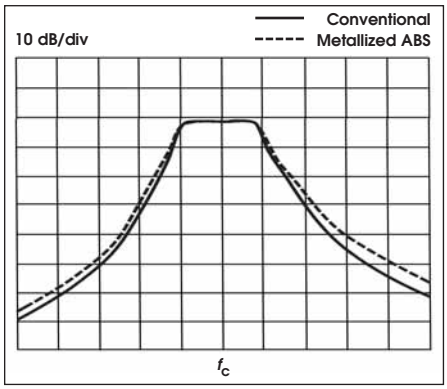

Figure 5 · Bandpass plots for the 600 MHz helical filter.

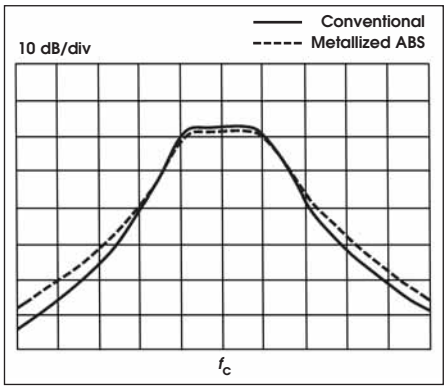

Figure 5 · Bandpass plots for the 4190 MHz combline filter.

Acknowledgement

The author wishes to acknowledge the assistance and support of the technical staff of the Institute of Technology and Management, Gurgaon, India.

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Author Information

Mr. Jagdish Shivhare joined the Institute of Technology and Management (ITM), Gurgaon, India, in 2003, after his retirement from the Indian Space Research Organization (ISRO). At ITM, he is Chairman of the Society of Electronics Engineers (SEE), Faculty Coordinator of ISTE and in charge of student-related activities. During his 20 years of service at ISRO, he was actively involved in R & D projects for ground and space applications. He has designed and developed devices such as high temperature superconductive filters, sub-systems and systems for different types of receiving terminals, earth stations and communication satellites such as ISTRAC, DRS, TVRO, IMESS, INSAT, INMARSAT, GPS, and Radio Astron. Mr. Shivhare can be reached by e-mail at: jshivhare.isro@gmail.com

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Improving the Bandwidth of Simple Matching Networks

By Gary Breed
Editorial Director

This tutorial describes methods for broadbanding matching networks using cascaded sections and compensating reactance

Impedance matching is probably the most engineering task in RF/microwave design. This tutorial is intended to demonstrate the first steps from simple two- and three-element networks that are designed for a specific center frequency, to larger networks that provide an acceptable match over a wider bandwidth. These wider bandwidth networks are important for modern communications systems that have operating bandwidths that are much wider than older technologies using FM and BPSK modulation. Even at narrower bandwidths, many digital modulation formats require flat amplitude and linear phase response, which can be achieved by using wideband matching networks, which have much smaller variation over a signal's occupied bandwidth.

Classic L, T and Pi Matching Networks

The simplest impedance transformation network is the L-network, which requires just two reactive components. Like a filter, the L-network can have a highpass or lowpass frequency response characteristic. Even if the particular response is unimportant, it means that two topologies are available—which is important when matching reactive loads, as we will see later.

Figure 1 shows the two L-network configurations and their design equations for resistive sources and loads. Note that Q is determined by the ratio of the impedances to be matched and cannot be chosen by the designer. Thus, L-networks are low-Q for small impedance transformations and high-Q for large impedance transformations. Also note that the equation for Q requires the shunt reactance to be located adjacent to the higher impedance.

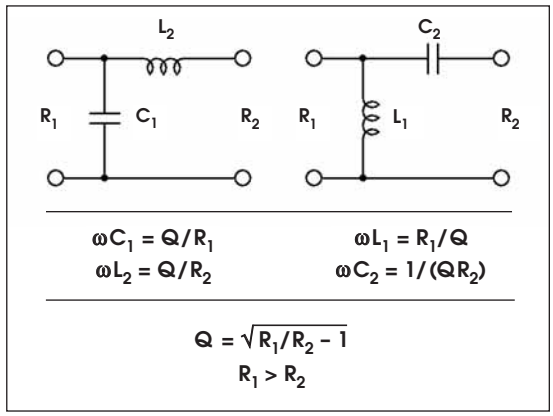


Figure 1 · The two basic L-network topologies and their design equations.

Two L-network sections can be connected back-to-back, as shown in Figure 2. The intermediate impedance at the center of the network is virtual (no actual load is present) and is selected by the user, usually to achieve a particular value of Q. Back-to-back connection requires this virtual impedance to be either

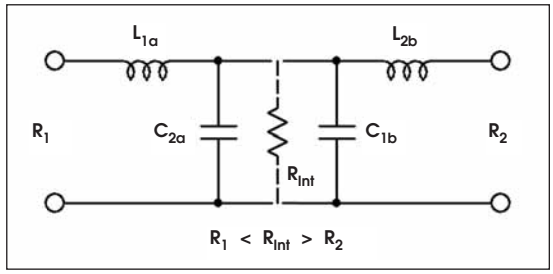
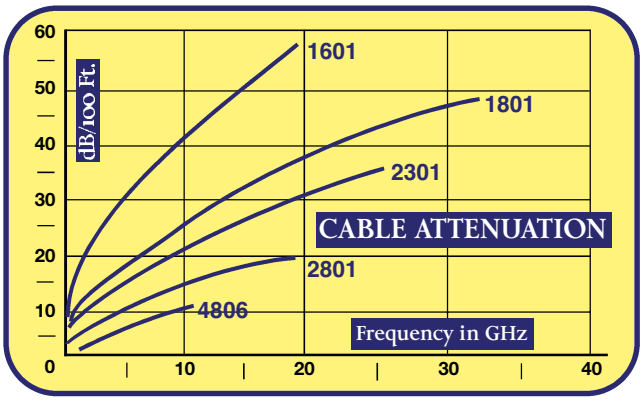
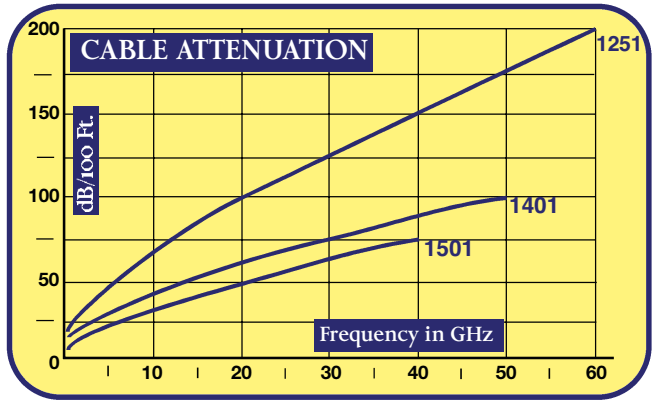


Figure 2 · Back-to-back L-networks with a user-selected intermediate impedance.





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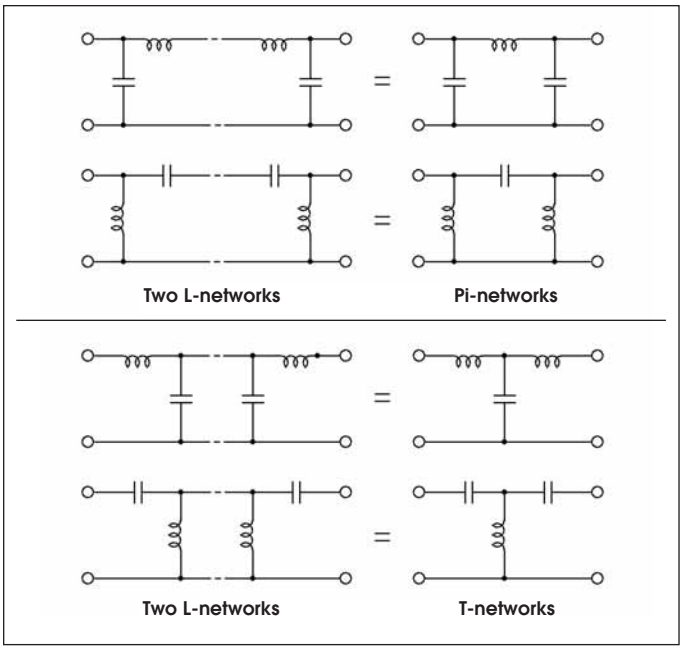

Figure 3 · T- and Pi-networks combine the center components of back-to-back L-networks. Additional topologies are illustrated in Ref. (1).

higher (as shown in Fig. 2) or lower than both the source and load impedance.

The center components of Figure 2 can be combined into a single component, with the result being the T-network. When the intermediate impedance is lower than the source and load, the result of combining the center components is the Pi-network. Figure 3 shows some of the ways that two L-networks can create T- and Pi-networks [1]. The choice among these topologies is determined by such factors as DC continuity and highpass, lowpass or bandpass frequency response. Practical component values are a major consideration in some cases, especially at high power levels.

Broadbanding with Cascaded L-Networks

Although T- and Pi-networks represent great flexibility in design parameter choices, they have narrower frequency response than a simple L-network. If wider bandwidth is the primary objective, L-networks can be cascaded in series rather than back-to-back, such as the 850 MHz 5-ohm to 50-ohm network shown in Figure 4 [2].

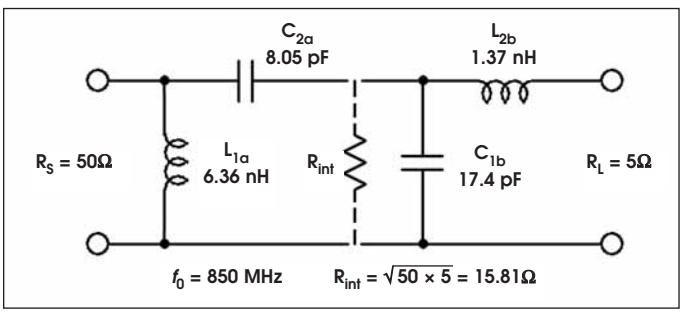

Figure 4 · Cascaded L-network example, with each section having a lower Q for improved bandwidth.

With cascaded sections, the lowest Q (and widest bandwidth) is achieved when the intermediate impedance is the geometric mean of the source and load impedances. For example, with source and load impedances of 5 and 50 ohms, a single L-network would have a Q of 3. When two sections are cascaded with $\sqrt{(50 \times 5)}$, or 15.81 ohms, as the intermediate impedance, each section has a Q of 1.47. With ideal, lossless components, the lower Q results in more than 3 times greater bandwidth near the center frequency (between the 0.1 dB points) [2].

Figure 5 is a plot of the impedance at the 50-ohm port for the cascaded network of Figure 4, compared to a single lowpass L-network. It is easy to see that the impedance deviation of the cascaded networks is far less than the single L-network section over this 35% bandwidth range.

Wider bandwidths and flatter impedance curves can be achieved by cascading more sections with the additional intermediate impedances creating smaller impedance ratios, and correspondingly lower Q for each section.

Incorporating Reactances

The above discussion was for resistive loads, but most practical applications involve loads that include reactance. The usual design procedure is to cancel the load reactance, then match the remaining resistive component to the system impedance. Figure 6 shows the two ways that reactance can be cancelled: (a) an equal but opposite sign reactance in series, and (b) a parallel reactance that resonates with the load reactance. A 5 –j5 ohm load is shown in this example.

The manner in which the reactance of the load is

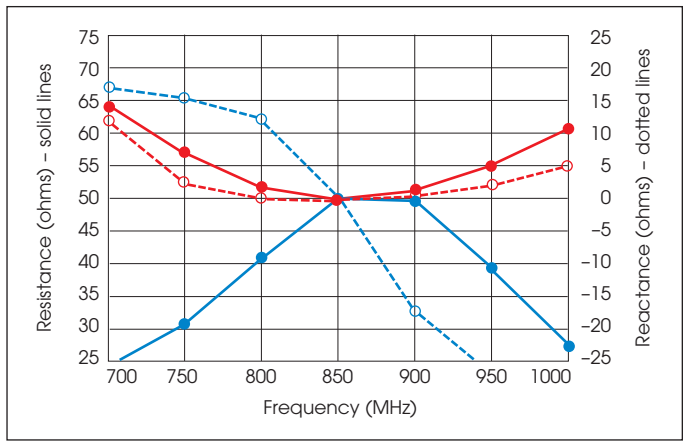

Figure 5 · Impedance at the 50 ohm port of a 5- to 50-ohm matching network: Example of Fig. 4 (red); Single section lowpass L-network (blue).

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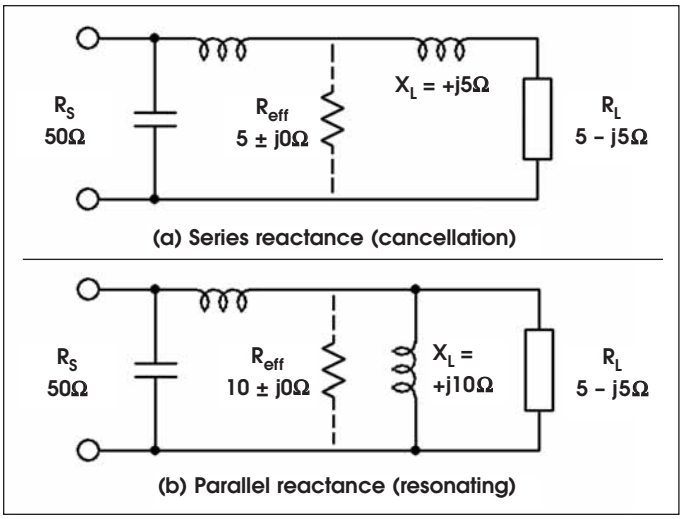

Figure 6 · Two methods for cancelling the load reactance, combined with matching the resulting non-reactive impedance to a 50-ohm system.

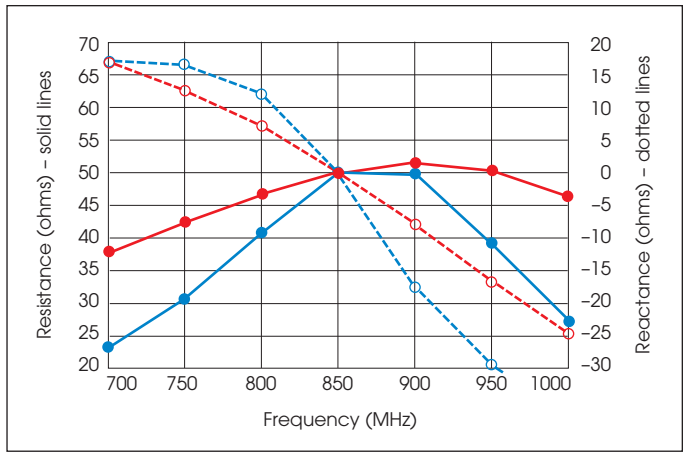

Figure 7 · Impedance at R_S port for the two matching options of Fig. 6(a) (blue) and Fig. 6(b) (red), implemented at f_0 = 850 MHz.

incorporated into the matching network affects bandwidth. The finished network can save a component by combining the series cancelling reactance with the adjacent matching component, but the resonating solution has a wider bandwidth.

In Fig. 6(a), note that the effective load is 5 ohms for the series cancelling method, but is 10 ohms for the resonating inductor method of Fig. 6(b). This reduces the magnitude of the impedance transformation by the L-network, which was previously shown to result in a wider matching bandwidth. While this circuit has significant variation in impedance away from the center frequency, this has a much smaller effect on bandwidth than the increased effective load impedance.

The results for this example, using a center frequency of 850 MHz, is shown in Figure 7, which is a comparison of the impedances at the source port for the two options of Fig. 6. The smaller impedance deviation for the resonating solution of Fig. 6(b) is clearly illustrated.

Some Additional Considerations

This tutorial has presented some of the "first steps" in the path from narrowband to broadband matching. There are many additional techniques that are involved in further bandwidth improvement, as well as for implementing matching networks with practical component values. Below are a few notes on some of those techniques, along with notes on other issues that arise practical matching network design.

Transmission line equivalents—All designs using lumped elements may use transmission line elements, as well. The choice depends on the physical construction method, frequency of operation and, in some cases, is used to replace components with non-optimum values.

Trading loss for bandwidth—Often, a very low resistance or high reactance load, such as the gate of some power FET devices, can be more easily matched for wide bandwidth by adding a series resistance to raise the effective impedance. When the additional loss can be tolerated, this technique can greatly simplify broadband matching network design.

Non-standard impedances—Many matching tasks involve interfacing between devices or circuits that are both higher or lower than the typical 50-ohm system impedance. Unless there is a need to test individual modules, or to separate the modules for isolation, matching the actual impedances will result in the simplest or easiest to implement network.

Practical component values—With several options for matching topologies, the choice between them will often be based on the component values. The considerations include loss (e.g., large inductors with relatively low Q), impractical component values, and high currents or voltages at the various points in the network.

Reactance of the load—The magnitude of the load reactance and the slope of reactance change across the desired band must be accommodated in any broadband matching network design. This will affect the choice of topology and complexity of the network.

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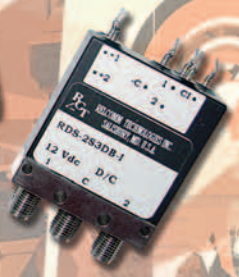

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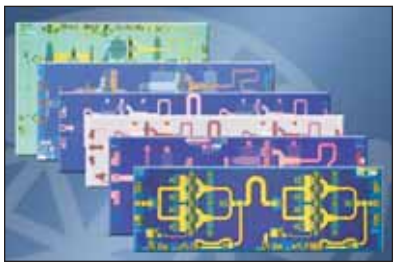

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RF/IF MICROWAVE COMPONENTS

427 Rev Org

Active Upconverting Mixer

Linear Technology introduces the LT5579. With a wide frequency range of 1.5 to 3.8 GHz, it covers the 1.9 GHz cellular bands as well as the 2.6 and 3.5 GHz WiMAX frequency bands. At 2.14 GHz, the device offers 27.3 dBm output IP3 linearity and 9.9 dB noise figure to deliver outstanding transmitter dynamic range. Moreover, the mixer has 2.6 dB of conversion gain, the highest in its class. The device integrates local oscillator buffers, requiring only –1 dBm to drive the LO port, while offering low –35 dBm LO-to-RF leakage. The LT5579 operates from a single 3.3V supply. Typical quiescent supply current is 226 mA.The device comes in a 24-lead 5 × 5 mm QFN surface mount package. Pricing starts at $5.50 each in 1,000 pieces quantities. The product is available immediately from stock.

Linear Technology Corporation
www.linear.com

USB Power Meters

Satori Technology has extended their product range of USB power meters with the release of the ST265. This pushes the frequency limit for high dynamic range USB power meters up to 26.5 GHz going beyond what is currently available in the marketplace. The ST265 now covers a frequency range of 10 MHz to 26.5 GHz. The ST series are complete miniature RF & microwave power meters. All measurement data and settings are sent via a USB interface to and from a PC or laptop. This gives the concept of using a computer as the user interface in classic microwave power measurement. Each power meter contains a CPU which controls the sensor, processes the measurement results and operates the USB interface.

Satori Technology
www.satori-technology.com

Test & Measurement Guide

Keithley Instruments, Inc. announces the release of its 2008 Test and Measurement Product Guide. This handy product guide offers details and specifications on Keithley's general-purpose and sensitive sourcing and measurement products, DC switching, RF switching and measurement, data acquisition solutions, semiconductor test systems, and optoelectronics test hardware. Tutorials simplify choosing solutions for specific applications. To request a free copy visit Keithley's Web site.

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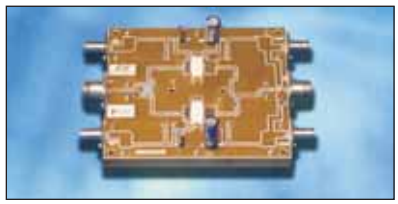

Broadband Doherty Amplifier

Nitronex has partnered with Prescient Wireless to develop a broadband Doherty power amplifier for WiMAX applications. Based on Nitronex's NPT25100, the design provides 20W linear power from 2.5 to 2.7 GHz while achieving over 30% efficiency, and 2% EVM with digital predistortion. Typical performance numbers were taken using a mobile WiMAX waveform defined as single carrier OFDMA 64-QAM 3/4, 10 MHz channel bandwidth, 9.5 dB PAR at 0.01% probability during the transmit portion of a 50% duty cycle TDD signal.

Nitronex
www.nitronext.com
Prescient Wireless
www.prescientwireless.com

Twisted Pair to Coaxial Balun

Pulse, a Technitrol Company, introduces its Excelsus brand B-V175 twisted pair to coaxial balun that allows digital subscriber line (DSL) or home phoneline networking (HPN) frequencies to be transmitted from twisted pair to coaxial mediums, and vice versa, to support VDSL2 and HomePNA™ deployments. The balun is easily installed with simple plug-in connections. It matches a 100-ohm twisted pair cable, which is a balanced signal, to a 75-ohm coaxial cable, which is an unbalanced signal, without degrading the signal. The B-V175 can pass frequencies from 25 kHz to 30 MHz from twisted pair to coaxial cable with less than 1.5 dB insertion loss across the entire frequency band. In addition, the B-V175 has a filtered phone port for "plain old telephone service" (POTS) telephones. The B-V175 meets FCC Part 68 standards. The parts are packaged in individual polybags, with prices of $6.50 for volume orders. Unit price may vary depending on configuration and shipping destination.

Pulse, a Technitrol Company
www.pulseeng.com

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Tyco Electronics offers the broadest range of RF Coaxial Interconnect products in the industry today. Our RF Coax portfolio is built on our strong heritage of the industry s leading brand names such as **AMP**, **M/A-COM**, **Microdot** and **Tyco Electronics,** as well as product lines formerly known as Omni-Spectra and Adams Russell.

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Solid State Power Amplifier Drivers

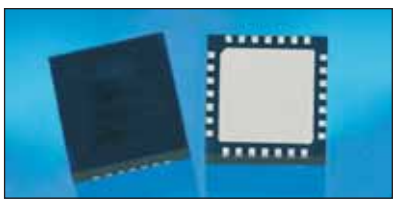
MITEQ introduces a new line of linear SSPA drivers. Three models cover all of the common satellite communication bands, AMFLD-05700850-60-16P for C-/X-Band, AMFLD-12501850-60-18P for Ku-/DBS-Band, and AMFLD-27003100-60-12P for Ka-Band. All three models have a common outline of 3.7" × 2.5" × 0.73", SMA connectors for RF I/O and a multi-pin connector for supply, controls and detector output. The linear drivers have a typical gain of 25 dB flat to within 1 dB, P_{1dB} of 16 dBm, and output IP3 of 26 dBm. Power monitor DC output and gain are well compensated, allowing for a compliant temperature range of –25 to +80°C. Also incorporated is 30 dB of linear gain control. Drivers have a noise figure of less than 6 dB, operate from a single 15V supply and draw 400 mA typical.

MITEQ, Inc.
www.miteq.com

Expanded High Speed Cable Line

Samtec has expanded its data rate high speed cable assembly offering with a new 75-ohm single-ended 38 AWG micro ribbon coax cable system (EQSD Series). This new assembly is available with vertical mount or edge mount sockets or terminals and mates with high speed Q Series® connectors on 0.8 mm (.0315") pitch. Application specific designs can be developed for mating with Q Series connectors on other pitches. This new 75-ohm system broadens Samtec's existing line of 50-ohm single-ended and 100-ohm differential pair data rate cable assemblies to three off-the-shelf impedance matched systems. They mate to Q Series connectors on 0.5 mm (.0197"), 0.635 mm (.025"), and 0.8 mm (.0315") pitches and Q2 Series connectors on 0.635 mm (.025") pitch. Samtec's line of data rate cables includes 100-ohm twinax edge card and high density DataBank™ assemblies, PCI Express® jumpers, combination Signal/QuietPower™ assemblies, and a variety of specific application test probes. Standard cables are available in a variety of lengths and with rugged features such as shielding, screw hardware, and latching options.

Samtec, Inc.
www.samtec.com



VSAT Power Amplifier

Tyco Electronics today launched the M/A-COM MAAPSS0111 amplifier, a new 13.75-14.5 GHz, four-stage, 1.25 watt power amplifier specifically designed for VSAT applications that require high efficiency. The MAAPSS0111 can be used as either a driver or an output stage amplifier. The amplifier is designed to generate 31 dBm of saturated output power while drawing 530 mA of current. The M/A-COM MAAPSS0111 has a typical power gain of 32 dB with an operating voltage of 8.0 V and typical IM3 of 26 dBc. The amplifier is housed in a RoHS compliant 6mm 28-lead PQFN package. The M/A-COM MAAPSS0111 is available from stock and is priced at $16.21 for quantities of 100,000.

M/A-COM
www.macom.com

Updated Software

ACS has recently released a new version of its LINC2 Pro RF and microwave design, synthesis and simulation software suite. Version 2.71 adds user defined equations to the LINC2 simulation control toolset. The latest edition also offers enhanced schematic capture, including an all new snap-to-grid feature for easy placement and alignment of components on the schematic page. The LINC2 Pro RF and microwave circuit design and analysis software suite combines circuit synthesis, simulation, optimization and statistical yield analysis into a single integrated design environment.

Applied Computational Sciences
www.appliedmicrowave.com

Quad-Band EDGE PA Modules

TriQuint Semiconductor, Inc. announced the first two members of its HADRON II PA Module™ family; the TQM7M5012 and TQM7M5005. These second-generation EDGE PAs were designed using TriQuint's CuFlip™ copper bump technology, improving RF performance while reducing current consumption to provide longer device battery life. Debuting with a 5 × 5 mm footprint, these solutions are 50 percent smaller than the previous generation, providing handset manufacturers additional

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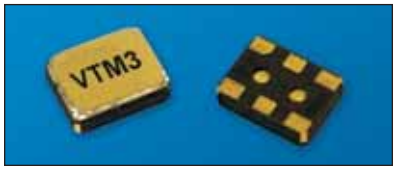
board space to add other rich features. The new products build on the success of TriQuint's first-generation HADRON PA Module™ family. TriQuint is currently sampling the TQM7M5005 and the TQM7M5012 to lead customers and production is planned for 1H 2008.

TriQuint Semiconductor, Inc.
www.triquint.com



GPS Quality TCXO

Vectron International announced its smallest temperature compensated crystal oscillator (TCXO) to date. The new VTM3 TCXO offers similar phase noise performance to Vectron's proven VTC4 and VTC1 TCXOs in a 50% smaller package (3.2 × 2.5 mm), enabling customers in the communications, industrial, test and military markets to benefit from the flexibility of a smaller, lower power oscillator without compromising the tight stability and superb phase noise performance. The new VTM3 TCXO is optimized for use in a wide range of wireless RF applications, including in GPS, in-car navigation, pilot locator, security/tracking, WLAN, WiMAX and WiFi base stations, Bluetooth, digital cameras, PHS, RFID, test equipment, and wireless meter readers. Generally available as a fixed-frequency TCXO, the VTM3 can be ordered with a voltage controlled crystal oscillator (VCXO) function for applications such as seismic exploration, base station, video transport and WiMAX timing. And, with current consumption as low as 1 mA, the new VTM3 TCXO is ideally suited for battery powered applications. Vectron's new VTM3 is currently available.

Vectron International
www.vectron.com

High Frequency Coax Contacts

Sabritec has launched a new range of high frequency coax contacts for multi-pin connector applications. The high frequency coax contacts are engineered with a "float mount" design to ensure low VSWR at microwave frequencies by preventing air gaps at the mating interface and are spring loaded for optimum reliability. High frequency coax contacts are designed to fit in size 8 and 12 cavities for MIL-DTL-38999, ARINC 404, ARINC 600 and size Size 8 cavities for MIL-DTL-24308 D-subminiature connectors. These contacts offer exceptional RF performance, up to 26.5 GHz for Size 8 and 40 GHz for size 12 contacts, and are designed to be terminated to .086 diameter flexible cables (RG-405 equivalent).

Sabritec
www.sabritec.com

New Brochure

NDK (Nihon Dempa Kogyo Co., Ltd.) has developed a new four-page color brochure highlighting their frequency control products for these applications. The brochure reviews the in-vehicle and telematic applications. NDK's transportation components have proven to deliver excellent performance in the harshest of applications. Products covered in the brochure include crystals, TCXOs and XOs. Copies are available by calling 800-NDK-XTAL (635-9825) or by emailing sales@ndkxtal.com.

NDK (Nihon Dempa Kogyo Co., Ltd.)
www.ndkxtal.com

WiMAX Circulators

Renaissance Electronics Corporation has invested in the new development of carrier class components supporting WiMAX base stations. We have produced three new circulator designs that are high reliability, extended temperature devices with minimal insertion loss. The screw top design is better suited for mass production with consistent test results particularly at the higher 3.3 to 3.8

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Renaissance Electronics Corporation
www.rec-usa.com

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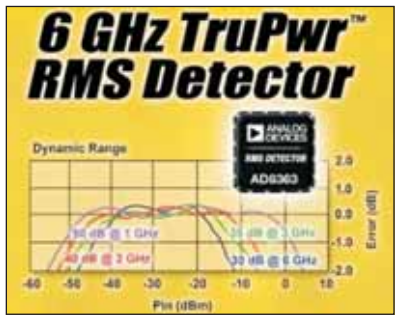
Tensolite introduces the LITEflight™ EP (Enhanced Performance) family of aerospace grade fiber optic cables. The new LITEflight™ EP series provides all the performance and benefits of its predecessor necessary to function in the harsh environments of your aerospace and military applications but with lower loss, tighter bend radius, improved thermal stability and better handling during termination and installation. LITEflight™ EP is available in multiple sizes, configurations and temperature ratings to 260°C in order to meet your application requirements.

Tensolite
www.tensolite.com

Linear Power Amplifier

Skyworks Solutions, Inc. unveiled a new high-efficiency linear power amplifier (PA) for wideband code division multiple access (WCDMA) handsets. The SKY77185, designed to address European market needs for the universal mobile telecommunications system radio access network, is currently sampling. Skyworks has shipped over 50 million WCDMA PAs as of December 2007. The SKY77185 3 × 3 × 1 mm band 1 PA with integrated coupler is a fully matched, 10-pad surface mount module developed for WCDMA applications. This small and efficient PA packs full coverage of the 1920-1980 megahertz (MHz) bandwidth into a single compact package. Due to high efficiencies attained throughout the entire power range, the solution delivers unsurpassed talk-time advantages. Samples of the SKY77185 FEM are currently available, with volume production scheduled for July 2008.

Skyworks Solutions, Inc.
www.skyworksinc.com



RMS Power Detector

Analog Devices, Inc. introduced the AD8363 TruPwr™ root-mean-square (RMS) power detector that precisely measures signals with highly varying crest factors up to 6 GHz used in WiMAX/802.16, WCDMA, TD-SCDMA, and LTE applications. The AD8363 is ideally suited for next-generation radio frequency (RF) applications using complex signals with highly varying peak-to-average ratios. The AD8363 achieves ±0.5 dB accuracy over the entire 50 dB ±1 dB dynamic range. The output is linear-in-dB, and scaled to 50 mV/dB, but other slopes can be arranged. The AD8363 is fully specified and stable over the entire frequency range of 50 Hz to 6 GHz, operating temperature range of –40°C to 125°C and supply voltage range of 4.5 to 5.5 V. The device is packaged in a compact 16-lead 4 × 4 mm lead-frame chip-scale package with a price of $5.25 per unit in 1000-piece quantities.

Analog Devices
www.analog.com

10-Watt 2 Way Power Dividers

BroadWave Technologies has developed a new line of 10-watt power dividers for antenna sharing and test applications. Models 151-218-002 and 152-218-002 are 2 way, 10-watt average power dividers with SMA female and N female connectors respectively. These 50-ohm units operate from 800 to 3,000 MHz and offer typical isolation of 25 dB. Maximum VSWR is 1.40:1 while insertion loss above the theoretical split is 0.75 dB maximum. Other configurations and connector types are also available.

BroadWave Technologies
www.broadwavetech.com

Power Amplifier Features On-Chip Power Detector

Mimix Broadband, Inc. introduces a driver and power amplifier pair offered in RoHS compliant, standard 3 × 3- and 4 × 4-millimeter QFN plastic packages, covering 12 to 16 GHz. The XP1042-QT driver amplifier provides +38 dBm OIP3, +25 dBm P_{1dB} and 21 dB gain, while the XP1043-QH power amplifier achieves +41 dBm OIP3, +32 dBm Psat and 20 dB gain. Both devices include on-chip ESD protection structures and DC by-pass capacitors to ease implementation and volume assembly. Samples are available today from stock.

Mimix Broadband, Inc.
www.mimixbroadband.com

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Matching Using Only 50Ω and 75Ω Transmission Lines

In the upper HF through UHF range, broadband ferrite transmission line transformers are not always practical, and microstrip or stripline circuits may occupy too much p.c. board area. Lumped elements are common, but an alternative is transmission line matching using common coaxial cables.

The most common coaxial cable impedances are 50 and 75 ohms, so this note looks at the range of impedances that can be matched using only these two types of coax. For simplicity, non-reactive impedances are used in these examples, but this method can match a wide range of reactive impedances, as well.

Transmission lines are easy to analyze on a Smith® chart, and there are several handy software-based tools that avoid the need for paper charts, compass, and other manual methods. winSmith 2.0 [1] was used for this note; see the References for other options.

The highest impedance that can be matched using these lines is 112.5 ohms, using a 1/4-wavelength 75-ohm line. The low-impedance range goes to near zero, since low impedance lines can be made by connecting multiple lines in parallel. In practice, any impedance between a few ohms and 112.5 ohms can be readily matched with the proper combinations of lines.

Examples: Matching to 30Ω and 90Ω Loads

Figure 1 Shows three possible combinations of coaxial lines that can match a 30-ohm load to a 50-ohm system impedance. The shortest overall length is the combination of 50- and 25-ohm cables, at 52.8º electrical length. The 25-ohm line would typically be made using two sections of 50-ohm line in parallel. Figure 2 shows the center portion of the Smith chart display for this configuration.

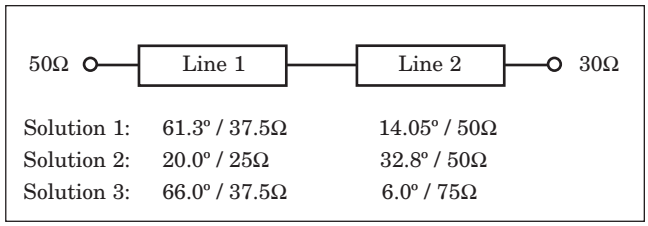
Figure 3 Shows two solutions for matching between a 90-ohm load and 50-ohm system impedance. The shorter total length is the one using 75-ohm and 37.5-ohm line sections, with 62.1º electrical length. Figure 4 is the Smith chart display.

Summary

By manipulating the lengths of lines with different standard characteristic impedances, the load and source points on the Smith chart can be "connected" over a wide range, allowing you to easily determine a match for antennas, devices or modules.

Smith Chart Resources

1. winSmith 2.0, available from SciTech Publishing: www.scitechpub.com



Solution 1:	61.3º / 37.5Ω	14.05º / 50Ω
Solution 2:	20.0º / 25Ω	32.8º / 50Ω
Solution 3:	66.0º / 37.5Ω	6.0º / 75Ω

Figure 1 · Three matching solutions for a 30-ohm load and 50-ohm system impedance.

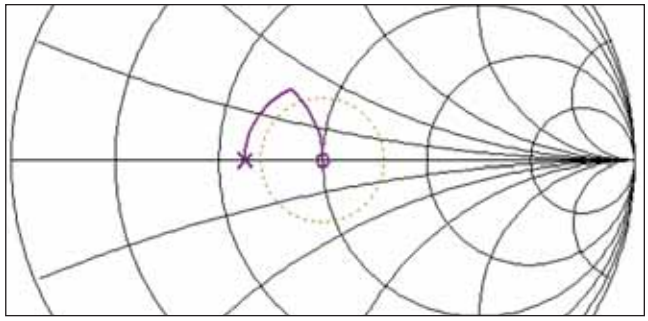
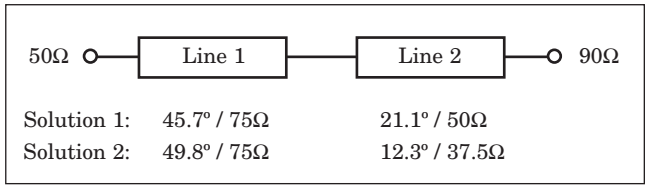


Figure 2 · Smith chart display for Solution 2 in Fig. 1. (The dotted line is the 1.5:1 VSWR circle.)



Solution 1:	45.7º / 75Ω	21.1º / 50Ω
Solution 2:	49.8º / 75Ω	12.3º / 37.5Ω

Figure 3 · Two matching solutions for a 90-ohm load and 50-ohm system impedance.

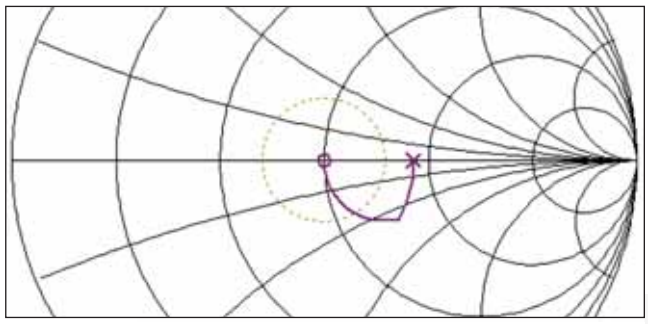


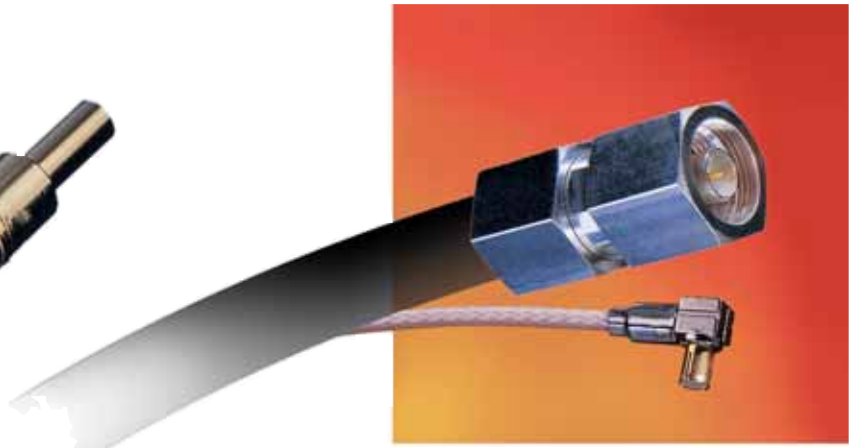
Figure 4 · Smith chart display for Solution 2 in Fig. 3.

2. Besser Associates, applet and tutorial notes: www.bessernet.com

3. Agilent Technologies, Smith chart info and applet: http://education.tm.agilent.com

4. RF Cafe, Smith chart applications for Visio and Excel, plus links to other resources: www.rfcafe.com/references/electrical/smith.htm

Custom.



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- Current or TTL control
- Low insertion loss
- High isolation

Frequency Range (GHz)	Model Number	Insertion Loss (dB, Max.)	Isolation (dB, Min.)	VSWR (Max.)	Rise/Fall Time (ns, Typ.)	On/Off Time (ns, Typ.)	On/Off Time (ns, Max.)	DC Power Positive/Negative (mA, Max.)
SPST								
0.2 – 2	SW1-002020RN1NF	1.7	70	1.6:1	10/10	20	35	35/70
2 – 8	SW1-020080RN1NF	2	80	1.7:1	10/10	20	35	35/70
4 – 12	SW1-040120RN1NF	2.2	80	1.7:1	10/10	20	35	35/70
2 – 18	SW1-020180RN1NF	3	80	2:1	10/10	20	35	35/70
1 – 18	SW1-010180RN1NF	3	70	2:1	10/10	20	35	35/70
SP2T								
0.2 – 2	SW2-002020RN1NF	1.5	70	1.6:1	10/10	20	35	60/60
2 – 8	SW2-020080RN1NF	1.8	80	1.7:1	10/10	20	35	60/60
4 – 12	SW2-040120RN1NF	2.2	80	1.7:1	10/10	20	35	60/60
2 – 18	SW2-020180RN1NF	2.8	80	2:1	10/10	20	35	60/60
1 – 18	SW2-010180RN1NF	3	70	2:1	10/10	20	35	60/60
SP3T								
0.2 – 2	SW3-002020RN1NF	1.6	70	1.6:1	20/20	150	180	85/85
2 – 8	SW3-020080RN1NF	1.9	80	1.7:1	20/20	150	180	85/85
4 – 12	SW3-040120RN1NF	2.4	90	1.7:1	20/20	150	180	85/85
2 – 18	SW3-020180RN1NF	3	80	2:1	20/20	150	180	85/85
1 – 18	SW3-010180RN1NF	3.1	70	2:1	20/20	150	180	85/85

Note: The above models are all reflective switches. Absorptive models are also available, please contact MITEQ.

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